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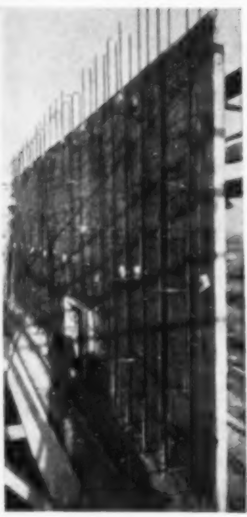

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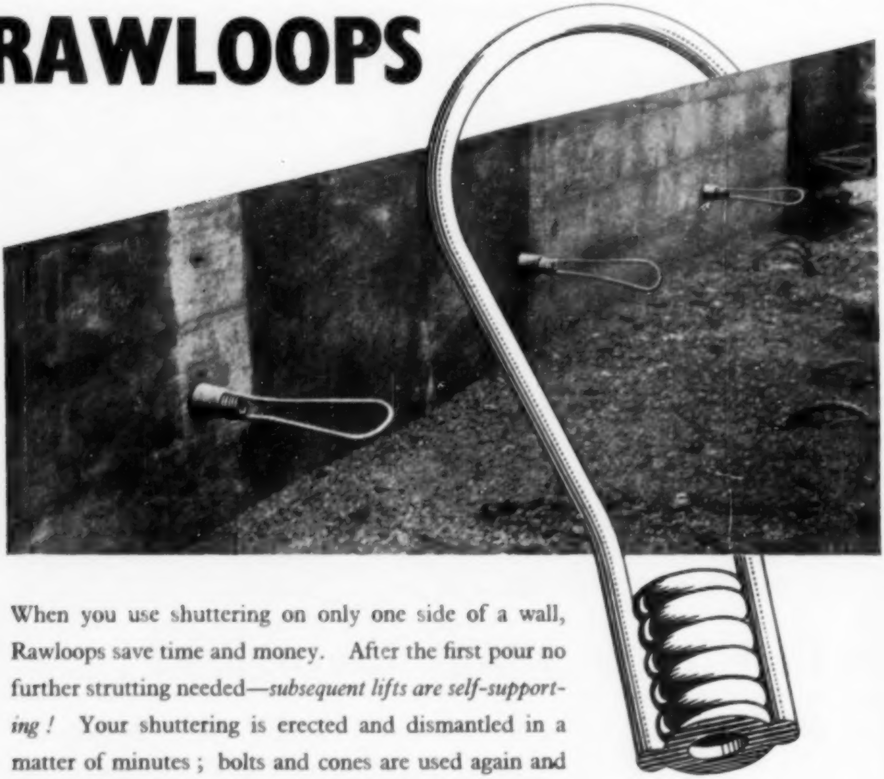

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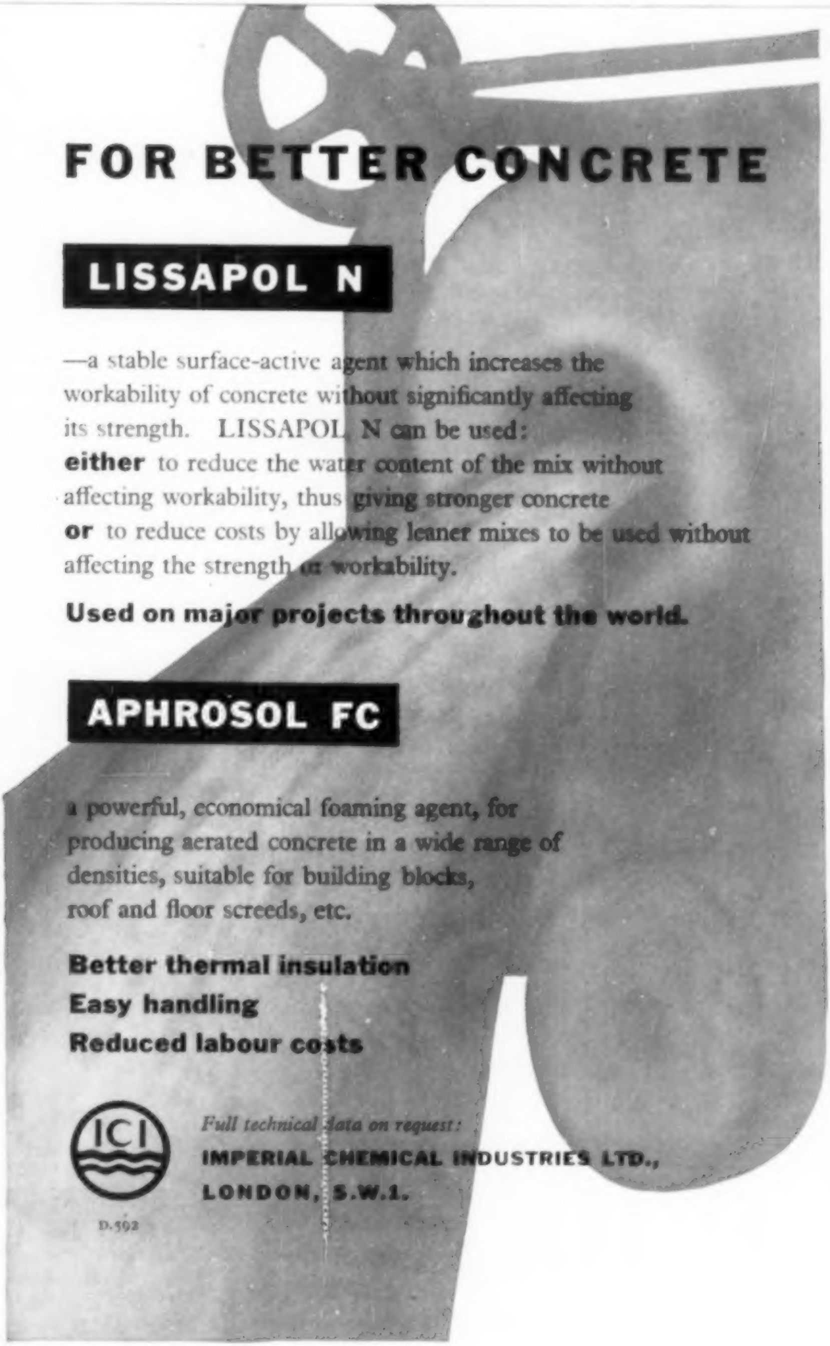
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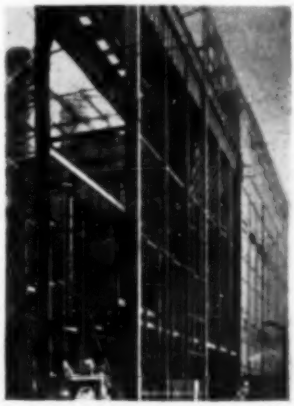


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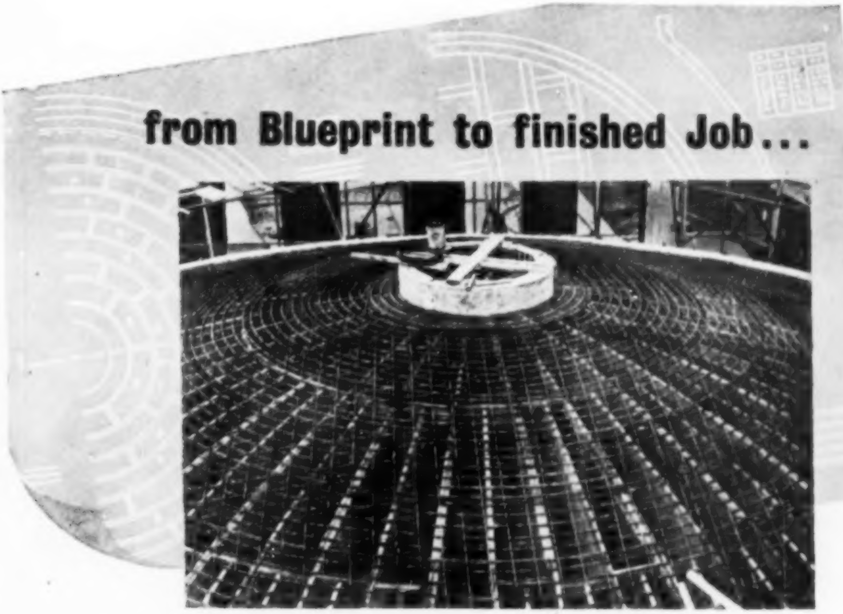

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CONCRETE
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Volume L, No. 9. LONDON, SEPTEMBER, 1955.

EDITORIAL NOTES

Shorthand for Engineers.

IN these days when, with a complete disregard of the meaning of words, it is said that the nation is in a state of full employment, anything that will enable us to do our work quicker must be seriously considered. From time immemorial mathematicians have used letters of the Greek alphabet and other signs as symbols that save writing words or phrases in full, and in commerce lb. is used for pound, cwt. for hundredweight, d for pence, and so on. More recently we have had the advantage of slide-rules and calculating machines. These are all useful devices that save much writing and arithmetic. There is no doubt that the use of abbreviations could with advantage be extended, as a correspondent suggests on page 335 of this number. In America in recent years some attention has been given to this problem, and new abbreviations have been invented for terms commonly used in civil engineering. Among these are psi for pounds per square inch, k for 1000, and kips for one thousand inch pounds. These are useful abbreviations, and are now coming into occasional use in this country. So far as the making of notes and calculations are concerned, the more abbreviations an engineer uses the better, and no doubt most engineers use abbreviations that they have invented themselves and that are used only by themselves ; these are excellent savers of time so long as there is no risk that the user will misunderstand their meaning. Much more time would be saved if the writers of reports and other documents were to use a system of shorthand that could be read by a typist.

Our correspondent, however, goes further, and recommends that psi be used in printed matter issued in Great Britain. With this suggestion we entirely disagree, for it assumes that British books are read only in this country and in Canada and the U.S.A., and ignores the fact that British books are sold in every country of the world. Of all books published in Great Britain about one third are sold abroad ; in the case of books published by Concrete Publications Limited the proportion sold abroad is more than two-thirds, and more than half the sales of this journal are abroad. It is known that many students abroad have to use a dictionary when studying British technical books, and a dictionary will not help them to find the meaning of psi or kips. When we reach maturity we do not spell out words as we read them, but visualise them, and it is as quick to visualise lb. per square inch as psi ; both terms and their meaning are seen at a glance. Many engineers could save a little time and gain in accuracy by writing lb. instead of

lbs. as a contraction for pounds. The derivation of lb. is the Latin word libra, the plural of which is libræ, so that it is quite wrong to write lbs. for pounds.

We see many reasons why an engineer should write psi for pounds per square inch, tsf for tons per square foot, or any other shorthand that he can invent in order to save time in making calculations, but this is not a good reason why such shorthand should be used on the printed page. In writing for publication, such shorthand may save a little of the writer's time and a little of the printers' time at the cost of the puzzlement and waste of time of perhaps thousands of readers who are not familiar with the latest technical shorthand emanating from the U.S.A. or elsewhere. The abbreviations k and kips suffer from two further serious disadvantages. One is that in this country the letter M has always stood for one thousand, and is still so used in the printing and perhaps other industries ; also, some newspapers use M to denote million. It is confusing to have the letters k and M both meaning thousand, and to have M meaning either thousand or million. The second disadvantage, is that abbreviations of numbers are always liable to cause mistakes, particularly when large numbers are concerned, and it is easy to forget that three noughts must be added to the written or printed figure. For the sake of accuracy we much prefer, for example, 330,500 in.-lb. to 330·5 kips—kips is not even shorthand, for where is the saving between writing 330·5 kips and 330,500 in.-lb ? If such terms are used their meaning should be prominently displayed at the beginning of every article or book in which they are used. Time is, of course, important, but not so important that we must ask for pap when we want pen and paper. Had the Americans given a little more thought to this matter they would have remembered that psi is the name of the Greek letter ψ, and pounds per square inch would have been reduced to one character instead of three.

Our own experience suggests that some engineers and technical writers could save much more time by not writing unnecessary words. For example, a Bulletin issued by the Building Research Station some years ago was at pains to explain that " The standard of protection called for in the case of roofs will remain much the same in all localities and must in fact be such that there is no chance of water penetration ". This could all be said, with much more clarity, in five words—" The roofs must be watertight ". Another Bulletin of the Building Research Station stated : " Where it is found necessary to use a concrete floor the following points should be considered. The function of the concrete base is to distribute local floor loads over a sufficient area of floor to sustain them. This must induce bending moments in the concrete and, therefore, the quantity and strength of the concrete must bear some relation to the nature of the ground and the magnitude of the loads on the floor. The best that can be done when cement is to be saved is to devise empirical rules based on the known properties of the concrete, at the same time incorporating the experience of floor constructors and users." This jumble of words seems to mean that foundations and floors must be strong enough to carry the loads, and that if the reader does not know how to design a floor he should make a guess after asking someone who does know. It seems rather absurd to use kips and psi (or even ψ), the meanings of which are not generally known, when much more time could be saved by refraining from using unnecessary words.

Our correspondent's suggestion that quantities of steel be written in tons and pounds only is a useful one, which we commend to the steel industry.

Design Assumptions and the Behaviour of Prestressed Concrete.

By P. W. ABELES, D.Sc., M.I.Struct.E.

THE writer has been associated since 1948 with the supervision of the manufacture of prestressed concrete by the pre-tensioning process in factories and by the post-tensioning process on sites. As a result of this experience, together with observations made at numerous acceptance, static, and fatigue tests to failure and of the causes of impact cracks, and a study of various publications, the writer has come to the conclusion that great discrepancies may occur between the assumptions usually made in design and the actual behaviour of prestressed concrete. These discrepancies may in some cases result in temporary or permanent cracks in a section in which it is assumed that compression only will occur, whereas in other cases, when the design assumptions are closely related to practice, freedom from cracks is ensured even when the design is based on the presence of tensile stresses under a working load of up to 750 lb. per square inch. Discrepancies between the assumptions used in the design and actual behaviour can be avoided by using design assumptions that can be realised by close supervision during manufacture. It is, for example, possible with prestressed precast members to have good and reliable agreement between design and performance, as described by the writer in this journal for May, 1954.

In the following, various causes of discrepancies are discussed. The type of construction should be considered in designing a structure, for example whether it is monolithic or composed of prefabricated parts. In the latter case predetermined cracks are present unless satisfactory strength is ensured by mortar joints. Different considerations apply to these types of construction with regard to conditions at working load. For example, a monolithic beam in which no cracks occur before prestressing has a definite and reliable tensile resistance which is not available in a beam composed of blocks without, or with unreliable, mortar joints. Another very important point is the exact assessment of the losses of prestress so that the effective prestress actually available is known. This is a difficult problem since shrinkage and creep may be very different according to whether the concrete is hardened in a dry or a humid atmosphere, and also according to the humidity of the atmosphere and the stress to which the structure is subjected when it is in use. The designer seldom knows exactly the conditions under which the members will be made, and therefore has to allow for the most unfavourable possibilities. A difference between the expected and the actual behaviour may also occur when the prestressing forces are not well distributed in the tensile zone, but are concentrated far apart. In this case the prestress may not be distributed over the entire area of concrete between the cables, and cracks may occur in spite of the presence of nominal compressive stresses.

In the following, the various possibilities which may cause discrepancies between the assumptions used in the design and the actual behaviour of a prestressed concrete member are briefly discussed and the possible consequences investigated.

Cracks before Prestressing.

Shrinkage cracks may occur before the prestress is applied and, unless they have completely healed, such cracks will open as soon as tensile stresses are developed. In this event the co-operation of the tensile zone, which may have been considered to be available either by allowing tensile stresses or considering it as a reserve against cracking, is not available. Such cracks can be easily and cheaply prevented in precast elements by moist curing, but in the case of large constructions built in situ it might be difficult to avoid shrinkage cracks unless special joints are provided.

In constructions built in situ, settlement may cause cracks before the prestress is applied. These cracks may occur if the load is not uniformly distributed on the ground or if heavy vibration occurs due to traffic; such cracks may impair the co-operation of adjacent parts, with the consequence that the properties of the cross sections and the moduli of inertia are different from those assumed in the design.

It has been generally considered that some shrinkage will take place before the prestress is applied. If that is so there is a possibility of shrinkage cracks occurring before the application of the prestress. Such cracks should, however, be prevented by careful moist curing before the prestress is applied. Moist curing has the advantage of making available the tensile strength of the concrete, which may amount to as much as 50 per cent. of the effective precompression. Shrinkage may be considerable, even under favourable conditions, in the absence of moist curing, particularly when the surface area is large compared with the volume so that the concrete dries out quickly. If the concrete is well cured shrinkage is delayed, as has been found in the case of reinforced concrete circular tanks in the U.S.A. Mr. J. M. Crom * reports that these tanks were well cured and immediately filled with water. They remained watertight for many years in spite of the low prestress in the mild-steel bands, but as soon as they were emptied during a hot period cracks developed owing to delayed shrinkage. Bearing this in mind, the entire shrinkage should be considered as a loss after prestressing. This is somewhat in contradiction to the general practice according to which a smaller shrinkage need be taken into account in the case of post-tensioning than in the case of pre-tensioning as, for example, is stated in "The First Report on Prestressed Concrete", issued by the Institution of Structural Engineers. However, if the concrete is well cured before prestressing, the same, that is the maximum, shrinkage will occur in both cases afterwards.

Creep.

Creep is one of the most important phenomena to be considered in prestressed concrete. It is encouraging to know good agreement is obtained for a relationship between the magnitude of creep in the course of time and the compressive stress so long as the latter does not exceed a certain proportion of the compressive strength. The study of rheology, that is the plastic flow of material on general lines, has resulted in the development of formulæ for the relationship of creep to time on broad lines. Creep of concrete was first considered some twenty-five to thirty years ago, and since then numerous publications have appeared in which

* "Design of Prestressed Tanks", by J. M. Crom. Paper No. 2481, Am. Soc. Civ. Eng. Transactions, 1952.

various formulæ are presented. It is interesting to know that J. Clerk Maxwell derived such a formula on general lines in a lecture on "The Dynamical Theory of Gases". In 1867 he presented, for solid viscous bodies under the strain $S = \frac{F}{E}$ (where F is the stress in Maxwell's original notation), the relationship $F = ET\frac{ds}{dt} + Ce^{-\frac{t}{T}}$. Maxwell defined T as the "time of relaxation". The formulæ for the time-creep relationship are useful since they indicate when plastic flow will be complete. However, this is correct only if the temperature and humidity of the atmosphere remain the same. When humidity is decreased and temperature increased, creep may commence again, although it may have been assumed that it had reached its maximum. Although the formulæ give a good basis for analysis, creep depends on so many circumstances unknown at the design stage that any attempt to predetermine it accurately is bound to fail.

Loss of Tension in the Steel.

In most cases, with post-tensioning the steel wires or bars are tensioned one after another, and this causes elastic shortening of the previously-tensioned wires or bars. It is possible to commence with a higher tension in the first wire or bar and gradually to reduce the tension to such an extent that the computed prestressing force is produced in the concrete. If the same tension is applied to all the wires or bars losses occur due to elastic shortening of the previously tensioned steel. These losses may be nearly as much as half the losses due to elastic shortening which is usual in the case of pre-tensioning, and it is necessary to take into account these losses. The relaxation of the steel was previously either ignored or believed to be offset by a temporary overstressing. However, it appears to be advisable to consider also the possibility of some loss due to relaxation of the steel, which will be greater if the steel is not bonded to the concrete.

Total Reduction of Prestress.

The assessment of total reduction of prestress is of particular importance, yet it is at present the weakest part of the design of prestressed concrete. It is hardly possible to compute exactly the amount of shrinkage and creep that will occur during the hardening of the concrete and during the use of a structure unless the designer knows the exact composition of the concrete, and also the temperature and humidity to which it will be exposed throughout its existence. This has led to two extreme solutions. One is an over-simplification based on the assumption of a definite percentage of losses, entirely independent of the magnitude of the initial tensioning of the steel and the compressive stress in the concrete at the level of the centroid of the steel, both of which greatly affect creep. Losses of 13 per cent. or 15 per cent., which are often accepted for post-tensioning, may be correct in some instances but incorrect in others. Such assumed losses will be much too low when high compressive stresses in the concrete occur at "transfer", and particularly when a precast member is not erected immediately and the relieving dead load is applied when nearly all the creep has taken place.

It has been shown by Dr. W. H. Glanville that creep increases in proportion to the compressive stress in the concrete so long as the latter does not exceed

40 per cent. of the strength of the concrete. Sometimes the stress in the concrete is greater than 40 per cent. of the strength. This is not in accordance with the recommendations of the " First Report ", but it is assumed that a higher stress in the concrete does not matter since it is not sustained. However, in this case the creep may be much greater than that assumed. With post-tensioning a loss of 15 per cent. may occur in some cases but losses of 25 per cent. or more may occur in members that are stored a considerable time before they are erected and loaded.

Finally, losses due to friction should be correctly assessed, the magnitude depending on the type of cable or bar, the kind of duct (sheath), and the workmanship.

Over-simplification and Precise Calculations.

Quite different from the method of over-simplification is the assumption that it is possible to compute exactly the losses by predetermining all the properties of the concrete and the thermal conditions and humidity during hardening, and thus to obtain an exact value of the creep composed of various parts, each computed for a separate stage. Such a possibility is, for example, embodied in the German draft regulations,* and complicated formulæ have been derived to compute these losses exactly. Obviously, if there are various layers of tensioned steel in the tensile zone, and possibly also in the compressive zone, complicated relations apply. It is not the average compressive stress in the concrete at the centroid of the area of the steel that matters and results in a definite prestressing force; but the losses vary from layer to layer, and in consequence the exact centroid of the prestressing force does not really coincide with that of the area of the steel.

As in all cases of extreme over-simplification or over-pedantic attempts at a solution based on assumptions which are often themselves inexact, it is preferable to select a method between these extremes and base the losses on an assessment of the maximum possible losses that may occur under unfavourable conditions without, however, going into complicated computations. This will be shown later in an article dealing with the losses in the pre-tensioning and post-tensioning processes.

Factor of Safety against Cracking.

As already mentioned, tensile stresses in the concrete due to bending are often not permitted at working load without regard to the type of structure, that is, whether or not the concrete is capable of resisting tensile forces. This obviously results in different factors of safety against cracking, which will be very high if the tensile strength of the concrete is available and as low as unity if the tensile strength is not available, and where any under-estimation of loss of prestress or any other unfavourable difference between the assumptions made in the design and the actual work (such as a greater working load or a smaller cross section) would lead to cracking under working load.

If the tensile resistance of the concrete is available the factor of safety against cracking related to the live load may be as high as 2. This is the case if the

* See this journal for June, 1954. Spannbeton, Richtlinien für Bemessung und Ausführing. DIN. 4227.

tensile stress in the concrete due to live load is 1000 lb. per square inch, thus equalling the reserve due to the modulus of rupture which can be assumed to be of this magnitude for high-strength concrete as used for prestressing. If such a high factor of safety were really required in structures in which a tensile resistance of the concrete were not available it would be essential to have a minimum compressive stress of 1000 lb. per square inch in the concrete under working load. However, such compressive stresses of a definite magnitude have, to the writer's knowledge, not been suggested, and authorities and designers are generally satisfied when tensile stresses are avoided in the design. Thus in this case, even if full agreement is achieved between the assumptions made in the design and the actual behaviour of the member, the factor of safety is only unity.

It does not seem satisfactory to be content with no margin whatever in one type of structure and in the other type to require a factor of safety as high as 2, if both types of construction may be used for the same purpose. It seems reasonable to require in both cases a small but reliable factor of safety against cracking of, say, 1·2. For tensile stresses of 1000 lb. per square inch, in the concrete due to the live load, a factor of safety of 1·2 would, if no tensile strength were available, require a minimum concrete compressive stress under working load of 200 lb. per square inch: $FS = \frac{1000 + 200}{1000} = 1{\cdot}2$. This would make permissible a tensile stress of 670 lb. per square inch in the concrete under working load in cases where the tensile strength of the concrete could be taken into account, since $FS = \frac{1000 + 1000}{1000 + 670} = 1{\cdot}2$.

Tensile and Compressive Strength and Young's Modulus of Elasticity.

The tensile strength of concrete does not increase with age in the same way as the compressive strength. At a very early age it increases much more rapidly, but as soon as dehydration takes place, that is when moist curing is discontinued, the tensile strength is reduced. This is later offset by a slight increase after completion of the dehydration process, and eventually a tensile strength is reached which is slightly higher than that available at an early age, whereas the compressive strength may have doubled during this time.

It is generally assumed that there is a definite relation between Young's modulus of elasticity and strength, that is to say, a higher modulus of elasticity may be expected when the strength of the concrete is greater, though this increase need not be directly proportional to the strength. However, this applies only to ordinary mixtures containing suitable aggregates. There are some kinds of concrete for which Young's modulus is less in spite of a higher strength and thus the deformation is much greater. In addition, a much higher proportion of the deformation may remain permanently, and also the tensile strength may be less. Such a case due to the unfavourable influence of chalk in the aggregate was mentioned by the writer in this journal for May, 1954. Other cases of the unusual behaviour of certain kinds of concrete were discussed by the writer in this journal for August, 1940, and January, 1942, dealing with deformable concrete due to the use of unsuitable mixtures. It should be borne in mind that

test cubes do not indicate such particular properties, which may be very unfavourable. From the cube tests alone it might appear that a concrete is satisfactory, while strain measurements may indicate a greatly reduced modulus of elasticity and high values of creep, and tensile tests may prove a greatly reduced tensile strength.

Concrete of such abnormal properties is not suitable for prestressed concrete because of its great permanent deformation and increased creep. Its use should therefore be avoided save in exceptional cases when suitable aggregates are not available. In such rare cases, obviously much higher values of creep should be taken into account ; these may be as high as two to three times the ordinary values. Also greatly reduced moduli of elasticity and rupture, which may be as low as half the usual values, should be considered.

Modulus of Rupture.

In the foregoing a tensile stress of 1000 lb. per square inch has been considered as a suitable modulus of rupture for prestressed concrete with a cube strength at 28 days of about 7500 lb. per square inch, on the assumption that the bonded steel is well distributed in the tensile zone. Objection might be made that this value is too high, in view of some published test results in which lower values, for example 600 lb. to 700 lb. per square inch, are mentioned. However, these lower values must have been due to the lower strength of the test specimens (mostly not made in a factory) or to other causes already mentioned such as preliminary shrinkage cracks which had healed but opened and became visible at a certain strain, or less effective prestress due to higher losses than those assumed. The modulus of rupture is determined as the nominal tensile stress due to loading in a straight-line stress distribution of an elastic material at which visible cracks occur.

Sometimes the magnitude of this stress is obtained from observation only, based on the difference between the loads at which cracks first become visible and again on reloading. This method, however, gives correct results only if the first loading is continued until the cracks widen substantially and a state is approached, but not yet reached, at which permanent deformation would occur. As long as the cracks are fine (which is normally the case with well-distributed and bonded wires), much lower values for the assumed modulus of rupture are obtained since on reloading the cracks become visible not when the prestress becomes zero but at a higher load when appreciable nominal tensile stresses are present. This will occur if the cracks are still very fine at the maximum load before its reduction. Thus, the method mentioned is not satisfactory unless it is ensured that the cracks are so wide at the first loading that they open really at zero stress.

Another possibility of a lower modulus of rupture may occur if this is related to the stress at which some of the strain measurements appear to indicate the development of a microscopic crack (that is, cracks invisible to the eye even if a magnifier is used). Strain-gauge readings have shown that a kink in a load-strain diagram may develop at a lower stress than the modulus of rupture corresponding to the real, that is direct, tensile strength. However, this does not affect the modulus of rupture (that is the nominal stress at which cracks become

visible), even after a million repetitions of loading, as has been ascertained by fatigue tests reported in this journal for May, 1955. Some thorough investigations in this country and abroad have proved that a modulus of rupture of 1000 lb. per square inch is safe for the conditions mentioned, and may be more than 1100 lb. per square inch if the strength of the concrete is higher.

Good Bond Necessary with Pre-tensioning.

In the case of pre-tensioning, it is essential that any noticeable slipping be avoided. The efficiency of the bond depends mainly on the surface condition of the steel, its diameter, and the stresses in the steel and the concrete. In cases where good bond must be achieved, obviously any lubricant must be removed from the surface of the steel. This was realised early in the manufacture of prestressed products by the pre-tensioning process; when steel was not available that was free from a lubricant on its surface, thorough cleaning was necessary before use. Cleaning is not now necessary, since steel is supplied by the makers in a suitable state. However, it is important that the suitability of any new steel product of a certain diameter should be investigated and considered on its merits. A generalisation is not possible, and the experience in one country with a certain product cannot be applied in other countries to another product, which may have different surface conditions. For example, wire greater than 2 mm. diameter was unsuitable in Germany when Hoyer introduced piano wires for pre-tensioning on long casting beds, whereas in this country smooth wire of 0·276 in. diameter has proved satisfactory, as was reported in this journal for May, 1955. From this it should not be concluded that any wire of such a diameter must be suitable unless it has also suitable surface conditions.

When pre-tensioning is employed for precast products the concrete must be especially well consolidated at the ends of the products, particularly at the upper surface if tensioned wires are provided near this surface. Otherwise the bond of the wires near the bottom will be much better than of those near the top, and the effective prestress will be developed in the bottom portion at a certain distance from the end where a part only of the prestress is developed near the top, with the consequence that the stress distribution will differ from the assumptions made in the design and cracks may develop.

Deformation at Prestressing.

Another difference between design assumptions and actual behaviour will occur if the deformation of a member due to prestressing is prevented by the mould or the supports. This may be caused, for example, by excessive adhesion between the bottom of a prestressed member and the shutter. For this reason, if it is impossible to ensure that adhesion cannot occur, it is advisable to jack up precast members as soon as part of the prestressing force has been applied. In in-situ construction the supports should be adjusted to allow deformation; this will, however, often be difficult.

Temperature Changes.

Changes of temperature do not affect the efficiency of prestressed concrete provided that the concrete has gained sufficient strength, and that movement

of the structure or product is not prevented. However, in the manufacture of concrete members with pre-tensioned wires, great temperature changes may be dangerous in some circumstances. The writer does not know of any such trouble in Great Britain, where the daily temperature differences are not very great, and in most cases the precast members are manufactured in a factory under cover. In other countries prestressing is often carried out in the open air. In such cases it is essential to employ either steam curing or high-alumina cement so as to achieve quick hardening of the concrete. Otherwise the tensioned wires would extend and contract due to temperature changes at a time when the concrete had not sufficient strength and did not expand and contract at the same rate. It is most unlikely that in such circumstances an efficient bond could be developed between tensioned steel and concrete.

Prevention of Shrinkage Cracks.

There is no difficulty in making precast members without preliminary shrinkage cracks. The writer has ensured freedom from shrinkage and settlement cracks in all the precast members up to 100 ft. long with the supervision of which he has been associated. It has been possible to ensure this also in in-situ work except in one instance where impact cracks occurred due to excessive vibration due to traffic before prestressing. The development of such cracks at unforeseen places may, as already mentioned, have unfortunate consequences, insofar as the co-operation of a slab and beam in a T-section may be interrupted and the design assumptions thereby upset. This may cause increased stresses due to different properties of the cross-section and a different centroid, and excessive tensile stresses and greatly increased deformation may occur compared with the values obtained in design. In view of this it would appear advisable, where shrinkage or settlement cracks may occur, to make conservative assumptions with regard to the co-operation of the beam and the slab of T-sections or box sections cast in situ unless, by the use of sufficient mild steel reinforcement and by the prevention of settlement or shrinkage cracks, full co-operation of slab and beam is ensured when the prestress is applied.

Workmanship.

Difficulty in obtaining satisfactory concrete may occur if there is not sufficient space to insert an immersion vibrator. This does not occur when a vibrating table or external vibrators are used. It is often essential to consider the use of immersion vibrators at the design stage, except for products to be made by the pre-tensioning process in a factory. These considerations may result in placing the bent-up steel outside of thin webs, so that the concrete in the webs can be well vibrated. Obviously the bent-up steel should be embedded in concrete and the web thus widened locally.

Bad workmanship may cause a discrepancy between design assumptions and actual behaviour, as may occur if an inexperienced contractor has to make high-strength concrete. Strong concrete and the correct application of the prestressing force are essential, and careful supervision is of utmost importance. The writer does not agree that the design should allow for poor workmanship, and that supervision can be dispensed with. A low stress in the concrete is not economical,

and a high stress requires strong concrete, particularly at the anchorages. It is not sufficient to produce a design that makes allowance for possible faults. For example, the tensile strength of the concrete may be ignored and considered as a reserve, but this may lead to unfortunate results since, as already stated, in spite of such an assumed reserve, cracks may occur, whereas freedom from cracks can be ensured with appreciable tensile stresses, as the writer pointed out in this journal for May, 1954.

Supervision.

As already stated, the writer is of the opinion that reliable supervision, or in lieu of it acceptance tests, are essential. The correct prestressing force must be applied in the correct position, and no reserve will suffice to offset faults of unknown magnitude and of unknown kind in the manufacture. There is no guarantee of a high factor of safety against cracking based on design assumptions without the knowledge that manufacture has been according to these assumptions. One cannot count on imaginary reserves. With good supervision one can be sure that the prestressing force of the required magnitude is available at the required position and that the concrete has the required properties, and a very small factor of safety will suffice ; with anything less than good supervision, any factor of safety will be only imaginary and unreliable.

The tensile resistance of a monolithic beam is available or it is not available ; in each case, as already mentioned, a different type of structure is obtained, the second case relating to a beam with temporarily closed cracks. The assumption that the tensile strength of the concrete is a reserve against under-estimation of the losses of tension in the steel is wrong if such tensile resistance is not available. A real reserve should be provided in such a way that the maximum possible losses and the maximum possible working load are taken into account. If, however, the tensile resistance is available, different properties are obtained compared with a member in which this is not the case.

Summing up, it may be said that it is essential to make design assumptions that can be obtained in practice, but it is equally essential to ensure that the work is done so that these assumptions are valid.

Visit of Professor Pier Luigi Nervi.

THE Italian engineer Professor Pier Luigi Nervi is to visit London next month. On October 14 he will lecture on Concrete and Structural Form at the invitation of the Institution of Structural Engineers and the Joint Committee on Structural Concrete (representing the Cement & Concrete Association, the Prestressed Concrete Development Group, and the Reinforced Concrete Association). The lecture will describe some of his best-known works and the principles underlying their design—among them the Turin exhibition halls, the dance hall at Chianciano, the restaurant at Ostia, the stadium at Florence, factories and warehouses with "mushroom" columns and veined floor slabs, and the new UNESCO building in Paris, in the design of which he is collaborating as engineer with the architects Marcel Bruer and Bernard Zehrfuss. The lecture will be at the Friends' Meeting House, Euston Road, London, N.W.1, at 6 p.m. Tickets (free of charge) may be obtained by members of the Institution of Structural Engineers and of the Reinforced Concrete Association from the secretaries, and by others from the Cement & Concrete Association, 52 Grosvenor Gardens, London, S.W.1.

A Covered Market in Italy.

A COMBINATION of reinforced and prestressed concrete has been used in the construction of the covered market (*Fig.* 1) at Vergato in northern Italy.

The circular roof covers an area of 575 sq. yd. and is 81 ft. 4 in. diameter. It is supported by eight beams cantilevering from a cupola of 10 ft. diameter carried on eight inclined columns. The roof slab, spanning circumferentially between the beams, varies in depth from 4¾ in. to 10 in. The base of the columns is annular, with a greatest external diameter of 24 ft. and an internal diameter of 7 ft. 6 in.; it is 7 ft. 6 in. deep. At the periphery of the roof slab the soffit is 16 ft. above finished ground level. Details of the structure (with dimensions in metric units) are given in *Fig.* 2. Beneath each beam a concrete stall has been erected.

The main beams vary in depth from 2 ft. 6 in. to 1 ft. 4 in., the reductions in depth being in two steps at about the third points. Each beam is prestressed by cables of twelve 7-mm. wires. Some of the cables pass from the end of one beam across the cupola to the end of the opposite beam; others are anchored in pairs at the steps in the upper face. The wires are anchored in pairs by means of six wedges in a steel cylinder bearing against a steel plate cast in the concrete. After the beams were prestressed the steps formed in their tops were filled with cement mortar to provide a level surface. The remainder of the structure is of reinforced concrete.

The roof is designed for an imposed load of 40 lb. per square foot together with a wind pressure equivalent to a load of 20 lb. per square foot. The concrete had a minimum crushing strength of 5700 lb. per square inch at 28 days. The high-tensile wires were tensioned initially to 142,000 lb. per square inch, and after allowing for all losses were assumed to be stressed to 127,000 lb. per square inch.

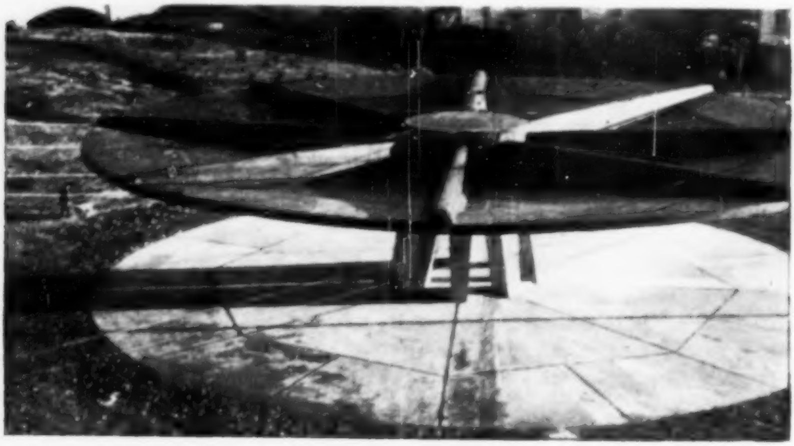


Fig. 1.

After the structure was completed one-half of the roof was loaded with gravel to an intensity of 40 lb. per square foot (the imposed load used in the design) and the maximum deflection of a beam was 0·7 in.

The structure was designed by Sr. Giuseppe Rinaldi in collaboration with Sr. Lancetti and Sr. Panicca of the Corpo del Genio Civile. The contractors were Cooperativa Muratori di Ionola.

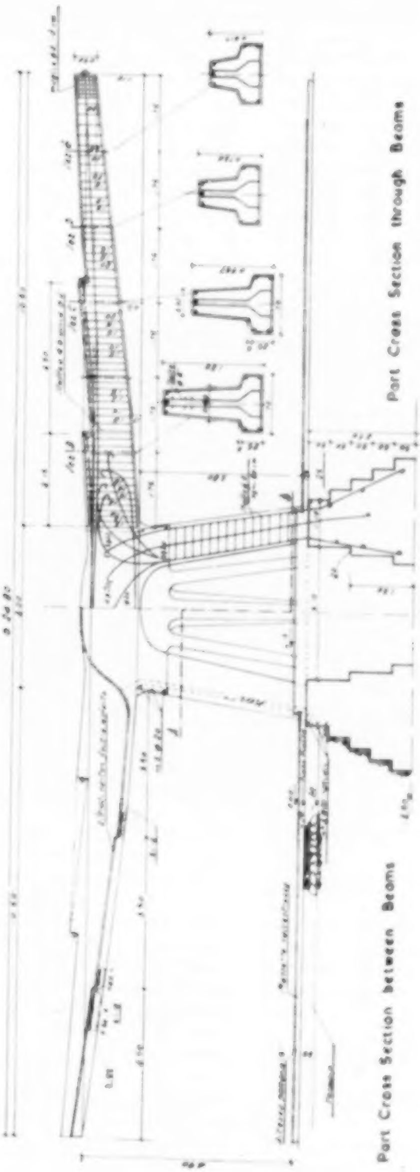


Fig. 2.
A Covered Market in Italy.
(*See facing page.*)

Book Reviews.

"Concrete Structures in India." [Bombay: The Concrete Association of India. Price Rs. 2.]

To those who are not familiar with the development of reinforced concrete in the East, this book of illustrations of reinforced concrete in India will come as a surprise. The first photograph is of a three-story reinforced concrete structure with architectural pretensions built as a hostel in 1907 and still in use. This is followed by many photographs of reinforced concrete structures, some in Indian style and others, such as a seven-story office building in Bombay, in the most modern style; the great Laxmi Narain temple at Delhi is amongst the most elaborate ornamental structures in the world. The bridges illustrated range from an arch bridge with a span of 52 ft. 6 in. built in 1908 to an arch with a span of 300 ft. and some prestressed concrete bridges. Industrial structures include hyperbolic cooling towers, shell roofs, silos, and chimneys. Some of the dams in India are well known, and new ones in course of construction include a gravity dam 1700 ft. long by a maximum height of 680 ft. and another 820 ft. long by a maximum height of 268 ft.

"Elementary Plane Surveying." By Raymond E. Davis. [London: McGraw Hill Publishing Co., Ltd. Price 41s. 6d.]

FIRST published in 1936, this well-known American book has again been revised. Comprising 490 pages, it deals with all aspects of land surveying, and is notable for a large number of tables. A new chapter is included on photogrammetric surveying.

"Laxton's Builders' Price Book." [London: Kelly's Directories, Ltd. Price 35s.]

THIS well-known annual, now in its 128th year, needs no recommendation. It has again been revised by Mr. P. T. Walters, and incorporates the new wage rates of April this year. In nearly a thousand pages it gives data on the cost of materials and labour for all the building trades.

"Les Poutres en Béton Armé soumises a la Flexion Composée." By G. Colorio. (Paris: Dunod. 1955. Price 960 francs.)

THIS book is entirely devoted to a method, derived by the author, of dimensioning and analysing the stresses in beams subjected to bending moments in two directions. Rectangular beams with symmetrically and unsymmetrically arranged reinforcement, and ell-shaped beams, are considered. About half the book comprises tables and diagrams which would assist materially in the solution of such a problem, but these are not of general application in this country as those relating to rectangular beams are based on a ratio of the stress in the steel to that in the concrete of 28, and those for ell-shaped beams are based on a ratio of 20. However, as the method is explained fully, those to whom the problem is important can tabulate similar information for any particular stress-ratio.

"Testing Concrete by an Ultrasonic Pulse Technique." By R. Jones and E. N. Gatfield. [Road Research Technical Paper, No. 34. London: H.M. Stationery Office. Price 2s. 6d.]

THE application of the ultrasonic method of testing concrete was described in this journal for November, 1954. In this paper are described the theory of the method and the apparatus used at the Road Research Laboratory, where this method of non-destructive testing of concrete, which was first used in the U.S.A., has recently been investigated.

"Practical Concreting." By A. E. Peatfield. [London: English Universities Press, Ltd. Price 6s.]

THE writer and publishers claim that this book is intended for the use of students of architecture, building, civil and structural engineering, engineers, building foremen, clerks of works, and many others, and that many of the chapters will be of assistance to the "ordinary householder". It may be that the attempt to cater for so many in 246 small pages of large type is the reason why the book will be of little use to anyone, but it cannot be an excuse for the many mistakes and misleading statements it contains.

Book Received.

"Studies of Boundary Value Problems." Part II, Characteristic Functions of Rectangular Plates; Part III, Oblique Plate in Oblique Co-ordinates. By Sven T. A. Ödman. [Stockholm: Svenska Forskningsinstitutet för Cement och Betong vid Kungl. Part II, price kr. 35; Part III, kr. 5.]

New Type of Precast Arch Roof.

A SITE of ten acres is being developed at Denton, near Manchester, to provide a factory for precast concrete, offices, and workshops for Messrs. Matthews & Mumby, Ltd. When completed the accommodation will comprise administrative and design offices, casting, bar-bending, and mechanics' shops. The casting shop is designed to take full advantage of mechanisation. There will be fourteen casting beds 150 ft. long, each containing two moulds for floor beams, with provision for prestressing on a long-line system, and it will be possible also to use the beds for reinforced beams. About 50 ft. of the remaining length of the shop will be used for non-standard members. Suspended from the roof and extending the whole length of the shop will be fourteen monorail crane-tracks each placed centrally over a casting bed. These will be used for distributing concrete from a central mixing plant and for carrying the hardened beams from the beds to one end of the shop where they can be placed on trollies and moved to the curing areas. Provision is made for heating the beds to enable a 12-hours' cycle to be maintained.

The casting, bar-bending, and mechanics' shops require large uninterrupted floor areas, and single spans of 90 ft. are used. The most suitable method of achieving this appeared to be a series of wide precast concrete arched frames with prestressed ties at the intersections of the arches and the columns (*Figs.* 1 and 2). The prestressing cables joining the springings of each arch are supported by fourteen hangers from which are hung precast beams of 25 ft. span carrying the monorail tracks. To achieve an even distribution of light over the working space, hipped

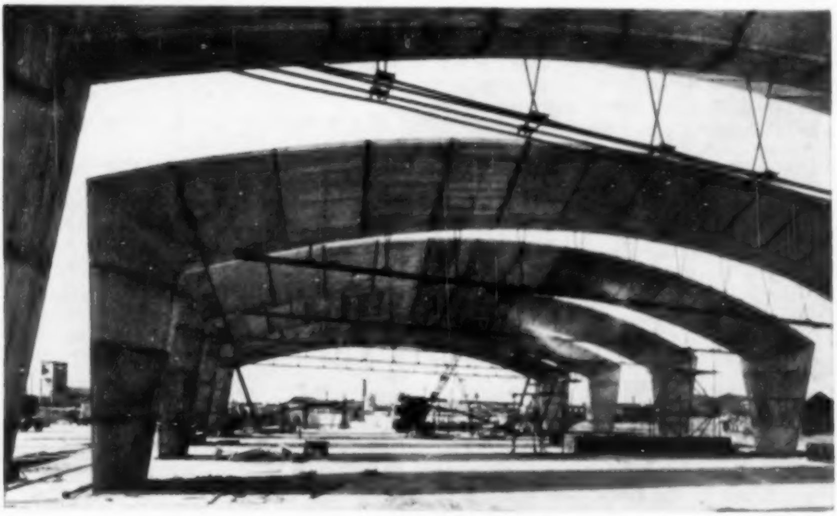


Fig. 1.—Frames Erected.

roof lights, 10 ft. wide, extend over the entire width. The V-shaped arches will act as reflecting surfaces to assist in eliminating glare, which will be further reduced by the "Venetian blind" effect of the longitudinal monorail tracks.

Design and Construction of the Frames.

Fourteen identical elements, 6 ft. long by 15 ft. wide, together with two end blocks form an arch, and there are three V-shaped tapering elements in each column. To reduce their weight for handling purposes the elements forming an arch have ribs on their upper surfaces

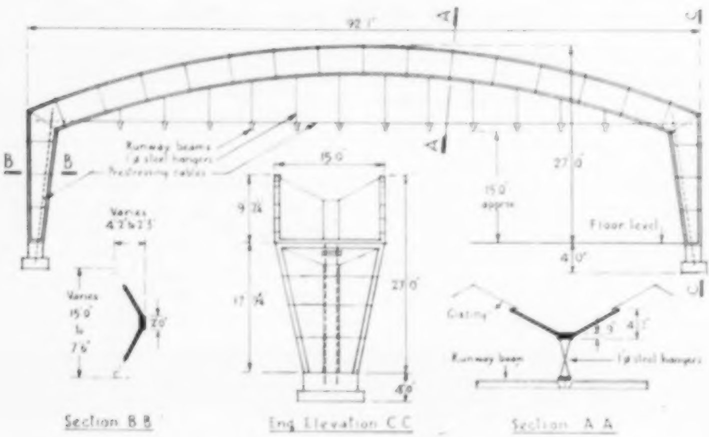


Fig. 2.—Details of Frame.

and the spaces thus formed are filled with concrete after erection. Four prestressing cables form the tie between the springings of an arch, and there are four external cables to each column. These column-cables are anchored at the top in the end elements of the arch and at the bottom in the in-situ base.

The frames are designed to carry the roof loads plus fourteen 1-ton loads from the monorail tracks. The bending moments due to the dead and live loads were first computed assuming the structure to be a monolithic frame. The bending moments due to a unit horizontal force applied to the corners of the frame were then calculated; these moments are of an opposing nature to those due to gravity loads. It was therefore possible to determine a prestressing force to be applied by the tie of such a magnitude that it imposed on the frame a bending moment equal but opposite in effect to that due to the dead loads plus one-half the live loads. In the final condition, therefore, when the live loads are not acting the frame is subjected to a bending moment tending to deflect the arch upwards, and when the live loads act it is subjected to a bending moment tending to deflect the arch downwards; the bending moment causing either of these deformations is half of the total bending moment due to the live loads only. Consequently the maximum stresses in an arch, due to working loads, are extremely low, being about 350 lb. per square inch in tension or compression. The prestressing cables in the columns are placed so as not to impose bending moments on the frame. Having calculated that a prestressing force of about 200,000 lb. was required in the completed structure it was necessary to determine the order in which the cables were to be tensioned having regard to the method of erection.

Erection of the Frames.

The precast elements are cast, in timber moulds, on the site in positions as near as possible to the frames of which they will form part. A steel lifting-frame is bolted to the element to allow it to be

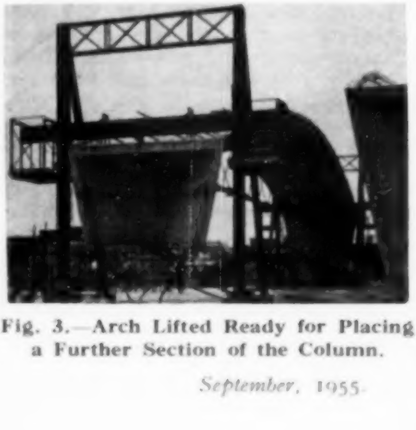


Fig. 3.—Arch Lifted Ready for Placing a Further Section of the Column.

tilted easily from its vertical position as cast to its horizontal position as placed. The arch elements are first placed on a light trestle of tubular scaffold which is mounted on wheels for ease of moving. The elements are raised by a mobile crane,

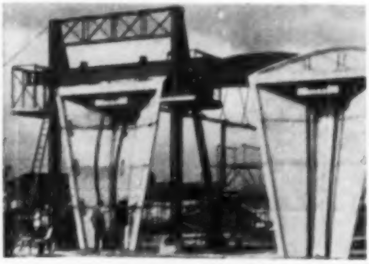


Fig. 4.—Columns Erected with Prestressing Cables in Position.

Fig. 5.—Placing Section of Column under Arch.

and between the crane-hook and the frame is a hand-operated hoist allowing an element to be lowered accurately into position. The elements are aligned and levelled by means of timber chocks and packings on the trestle. The elements are spaced 1 in. apart and the gaps are filled with a 3 : 1 mortar of sand and high-alumina cement. Alternate voids between the ribs in the arch elements are then concreted. After two of the cables have been tensioned the arch is raised by a steel lifting-frame at each end.

The two lifting-frames (*Figs.* 3 and 4) each consists of two braced columns formed of steel channels placed back to back, and with space between them in which slides the lifting-joist and bearing-plates for hydraulic jacks. Attached to the lifting-joist is a platform from which the jacks are operated. The bearing-plates are kept in position by steel pegs passing through holes in the webs of the columns. When the lifting-joists have been raised 9 in. they are pegged to the columns, the jacks removed, and the bearing-plates lifted to the next position for a further 9-in. lift. When the arch has been raised sufficiently a column element is mortared and attached by steel-angle cleats as shown in *Fig.* 5. When an entire frame has been made in this manner it is lowered on to a mortar bed and the four vertical cables in each column are stressed (*Fig.* 4). The third horizontal cable is tensioned after half of the remaining dead loads is added, and the fourth horizontal cable is tensioned when all the dead loads have been added. The horizontal and vertical cables are

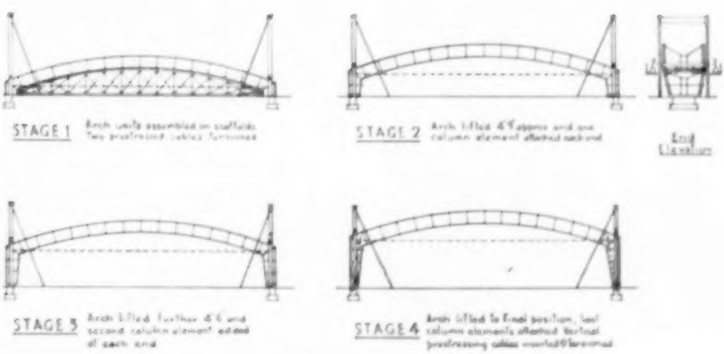


Fig. 6.—Stages in Erection of Frame.

contained in metal sheaths and will be grouted when the work is complete. The stages in the erection of a frame are shown in *Fig.* 6.

The architects are Messrs. Taylor & Young, of Manchester. The development of the structural system for the main factory and the civil and structural engineering generally are under the direction of Dr. D. D. Matthews, chief engineer of Messrs. Matthews & Mumby, Ltd., who are carrying out the work.

An Automatic Proportioning and Mixing Plant.

The concrete proportioning and mixing plant illustrated is described in "Engineering News-Record" for April 21, 1955. The plant is installed at a ready-mixed concrete depot of the Cleveland Builders Supply Co., and was designed by Fairbanks-Morse & Co., of Chicago. The plant is of the "automatum" type in which all the operations are controlled by electronics. The operator and the control panel (*Fig.* 1) are in the room with the projecting window seen in *Fig.* 2, and the orders are received by radio.

Punched cards, one for every mixture supplied at the depot, are dropped into the mechanism and automatically operate the electronic controls. In the required order and in correct amounts, any one of three types of cement, any of six different sizes of aggregate, and water are weighed into the mixer. The mixing time is also governed by the controls, as is the tilting of the mixer and its discharge. The controls can also be set to omit water and supply dry ingredients for mixed-in-transit concrete.

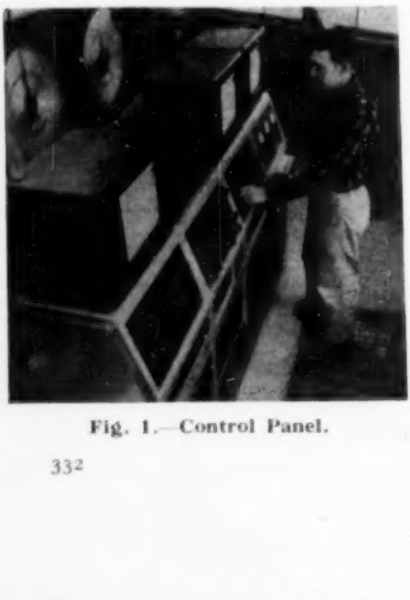


Fig. 1.—Control Panel.

Fig. 2.—The Batching Plant.

The plant has a capacity of 200 cu. yd. per hour. Compared with the Company's other three plants, in which men using hand levers control the flow of materials to the mixers, a saving of about £4250 worth of cement and £1400 worth of aggregates a year is expected. The reason for this is that, with hand operation, the amount of cement, for example, can be controlled only to within about 25 lb. of the amount required in a 6 cu. yd. batch, whereas with electronic control this variation is reduced to 4 lb. Similar reductions in variations are also obtained for the aggregates and the water.

On the arrival of a vehicle the operator drops the punched card into a slot in the control panel and pushes a button. The electronic controls then carry on operating the mechanism for proportioning, mixing, and discharging the concrete into the vehicle.

The plant is on a river bank, and the aggregates are delivered in self-unloading boats that discharge to storage piles.

The Late Professor Gustave Magnel.

We have received the following appreciations of the late Professor Gustave Magnel, whose untimely death was announced in our last number.

FROM F. G. RIESSAUW.

Professor of Reinforced Concrete,
University of Ghent.

For more than thirty years the late Professor Magnel consecrated himself to the University of Ghent and to his pupils. His lectures were characterised by a remarkable clearness, and were essentially practical as a result of his great experience in the design and erection of concrete structures of all types. He was interested all his working life in research, and was a member of the board of directors of the I.R.S.I.A. and vice president of the board of direction of the Belgian National Foundation of Scientific Research.

He early realised the importance of reinforced concrete, and his unrivalled foresight also immediately appreciated the possibilities of prestressed concrete. As early as 1940 he made in his laboratory (where I had the honour to be his Chef du Travaux) his first experiments in prestressed concrete, and devised his well-known method of anchoring the wires by means of " sandwich plates ". He was fortunate to see his process applied in very many structures throughout the world, the best known being the Walnut Lane bridge in Philadelphia, U.S.A. At his laboratory, which acquired world-wide renown, he always welcomed those who wished to improve their knowledge.

Magnel was a tireless worker, and at the time of his death he had in his drawing office many imposing projects. Death surprised him in full activity, just as he had completed the examinations at the University. All who had the good fortune of being his pupils and the numberless engineers who benefited from his advice, will cherish the memory of an enthusiastic man of science, who was undeterred by any difficulty and who never shirked responsibility. A passionate patriot, he resisted to his utmost during the German occupation and was forced to suspend teaching during the war.

His friends and colleagues are bewildered at the suddenness of his death. Time alone will permit us to measure the loss the scientific world, and civil engineering particularly, have sustained. At the University of Ghent, and in the minds of his pupils and colleagues and innumerable friends in Belgium and abroad, Magnel will be an imperishable memory.

[Since writing the foregoing, M. Riessauw has been appointed to the Professorship formerly held by the late Gustave Magnel.]

From PROFESSOR R. H. EVANS, D.Sc.

Department of Civil Engineering,
University of Leeds.

The death of Professor Magnel is a great shock to his many friends all over the world, for his friendship may truly be said to be world-wide. It was my good fortune to meet him for the first time in 1947 with Dr. P. W. Abeles in the offices of British Railways at King's Cross, London. Here, I thought, was a man from whose fertile and original mind came a constant flow of ideas on reinforced and prestressed concrete which he would never hesitate to pass on to those who could make use of them.

In 1950 it was my privilege to spend ten days at the University of Ghent assisting with his lectures and instruction classes. It was clear that his interest in the students knew no bounds, and he received from them great respect for his scholarship and affectionate appreciation. Methodical and efficient in his teaching, he nevertheless brought to his relationship with students a rare degree of human sympathy and insight, and generations of former students count his friendship as one of the most rewarding experiences of their university career. He certainly was a great teacher with a genius for making friends. Magnel was fond of controversies and, although differences of opinion on scientific matters can easily become acrimonious, it was characteristic of his personality that he never allowed such differences to influence his feelings.

In the writing of some seventeen textbooks, in his researches on reinforced concrete, prestressed concrete, and prestressed steel, Magnel spent himself without stint. To the end he pursued his life's work with devotion and singleness

of purpose. He acquired an international reputation, and was recognised as a master in the design of ingenious and new methods of concrete and steel construction. It is the privilege of few engineers to enjoy the satisfaction, which must have been his, of seeing many of his early ideas and researches receive universal recognition and be afterwards exemplified by the erection of so many types of structures in all parts of the world. These structures are worthy and permanent memorials to him.

It is almost a truism that the wife of an engineer often deserves an equal share in the credit of her husband's achievements. This is certainly true of Madame Magnel; for not only did she sustain her late husband in his scientific work and often accompany him on his travels abroad, but she participated fully with him in his wider cultural interests in the University.

All those who knew Magnel have lost a dear friend and colleague whose warmth of heart will be sadly missed. His gifts of friendly intercourse enriched us all by their genial and mellow qualities. In recording their sense of loss, his friends will wish to convey to Madame Magnel and her family their very deep sympathy.

FROM PROFESSOR A. L. L. BAKER, D.Sc.

Professor of Concrete Technology, Imperial College of Science and Technology.

Magnel was the complete civil engineer, equally competent to discuss research, new theories, and practical application. He believed in simplicity, and could reduce complex analysis to the bare essentials and so produce formulæ which could be easily used by designers. He always published such work, and generously passed on his knowledge for the benefit of others. I often heard him speak at conferences and was impressed, as were so many others, by his great power as a lecturer in the English language. On several occasions he fascinated large audiences when describing his work and enunciating his theories at the Institution of Civil Engineers.

My wife and I were in his laboratory as recently as mid-June of this year, when he was as enthusiastic as ever about his work, particularly his design for a tower over 2000 ft. in height in prestressed concrete for the 1958 Brussels Exhibition. He showed us a very fine model of this, and also the various research projects proceeding in his laboratory. He had recently returned from a lecture tour in Jugoslavia and was clearly extremely busy, but he devoted a whole morning explaining to us the research in progress and giving much valuable advice on equipment. He then showed us some of Ghent's famous historical buildings. Such kindness and generosity must have been received from him by so many. Belgium, indeed the whole world, owes much to this great engineer who devoted his life to the advancement of his subject.

FROM DR. P. W. ABELES.

I first met the late Professor Magnel in the year 1945, and since then he has been a welcome visitor and friend. I was greatly impressed by his strong character, and I was not surprised when I learned that he preferred to go to prison during the war rather than to retain his professorship at the University of Ghent on condition that he collaborated with the Nazis, who had demanded that he should prepare designs for them. Fortunately the term of imprisonment was short, and after his release he was allowed to carry on with his work as Director of the Laboratory, although he was forbidden to teach. These secluded years at the laboratory gave him the opportunity of undertaking research on prestressed concrete, including an investigation on the creep of steel, and of developing his post-tensioning system in collaboration with the contractors Entreprises Blaton Aubert of Brussels.

He told me that his approach to his system of prestressed concrete was initiated by noticing that in testing a beam the load often increased further before failure notwithstanding the fracture of one post-tensioned wire after another. He recognised also the great losses due to friction when the cables were tensioned, and observed that the measured elongation was less than that corresponding to the applied force. This resulted in his suggestion of the provision of steel spacers between the wires to be tensioned, not simultaneously but in pairs.

After the war Magnel introduced the practical application of prestressed con-

crete on a large scale in Belgium. Those who attended in 1948 the Third Congress of the International Association for Bridge and Structural Engineering at Liége saw some of this work, such as the roof of the aircraft hangar at Melsbroeck near Brussels with box-shaped precast girders 164 ft. long and weighing 270 tons, a textile factory at Ghent, and several bridges, as well as his laboratory which had been newly built after the war. In 1951 he arranged the first International Congress on Prestressed Concrete at Ghent, when again there was an opportunity of seeing some of his work and to appreciate his personality as a host. He was greatly interested in continuous structures in prestressed concrete, and published his theory on this subject in this journal in 1947; the famous Sclayn bridge is a notable example of his work in this direction.

I visited Magnel at his laboratory several times and met him elsewhere in different parts of the world. At Zurich in 1953 he and Professor Rüsch of Munich and myself lectured at a conference on prestressed concrete, arranged by the Swiss Association for Testing Materials. It was then I noticed for the first time that he suffered from heart trouble.

The structures designed by Magnel in prestressed concrete have been a very important factor in the rapid development of this new type of construction since the war, and his contribution was furthered by his writings, research, and lectures. He was an excellent lecturer, able to present his case in a lucid and interesting way, and he was also an excellent teacher. As a practical engineer and in his teaching of the subject he favoured a very high factor of safety so as to avoid any possibility of a set-back in the development of this method of construction. Although he had strong views on technical matters, his nature was so amiable that it was a pleasure even to disagree with him. He was a charming host who enjoyed social functions and the company of others, and he liked travelling. His great pride was his working room overlooking his laboratory.

Magnel was looking forward to the congress on prestressing at Amsterdam two months after his passing, at which many friends will miss his charm and ever-willing help.

Saving Time by the Use of Abbreviations.

Mr. Donovan Lee, B.Sc., M.I.C.E., writes as follows :—

May I ask you and your technical readers whether the time is not over-due when lb. per sq. inch should be replaced by " psi " in order to save the time of engineers and printers? This would also result in more uniformity with American practice, and make it easier for engineers in the United States and Canada to read technical books and articles published in this country. The tendency to use psi instead of lb. per sq. inch already exists, and the " Indian Concrete Journal " may be mentioned as a publication that uses it consistently; there is also a tendency to use this abbreviation in connection with prestressed concrete.

If the leading technical journals in this country were to use this abbreviation consistently the practice would very promptly become general. It may be thought that this is too trifling a matter to warrant mention, but anything that saves time and improves international standardisation should, I think, not be overlooked.

On the question of saving time, it must seem to many in this country, as well as overseas, ridiculous that we still give quantities of structural steel and reinforcement in tons, hundredweights, quarters, and pounds. When the total labour of invoicing steel in this way is considered it seems surprising that there has been no real effort to change to tons and decimals of tons, or to tons and pounds, or to use the short ton for all calculations relating to steel.

Perhaps I have sown the seed of one or even more new committees, and perhaps the arguments that can be produced in favour of continuing present methods will be surprising. However, in the past arguments have been brought, even in very recent years, against revised methods or new materials that we could not do without to-day.

A Multiple-story Garage in the U.S.A.

A MULTIPLE-STORY garage, considered to be the largest in the U.S.A., has been built at Arlington, Virginia, and was described in a recent number of "Engineering News-Record". *Fig.* 2 shows a plan of the second floor and a longitudinal section through the building. The construction is two-way flat slabs with columns at 30-ft. intervals in the length of the building and 27-ft. intervals transversely. To avoid obstructing the display windows in adjoining stores and to increase the space available for cars the slab cantilevers 15 ft. at the ends of the building and 13 ft. 6 in. at the sides. The slab is 10½ in. thick with drop panels 10 ft. 6 in. by 9 ft. 6 in. by 5¼ in. deep, and in the first interior bays the column bands are made the depth of the drop panels to allow for the unusually long cantilever slabs. Details of the reinforcement in the column bands are shown in *Fig.* 1. The column capitals are 6 ft. 6 in. diameter and the largest column, carrying a load of 450 tons, is 34 in. diameter.

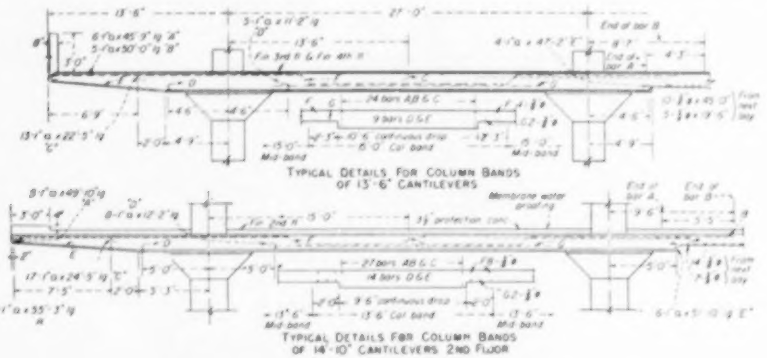


Fig. 1.—Details of Typical Cantilevers.

The access ramps are of beam and slab construction, the slabs being 6 in. thick with a 1-in. wearing surface, and sloping 10 ft. in 90 ft. Expansion joints, 2 in. wide, separate the garage from the adjoining building and there is a similar joint across the width of the building 255 ft. from one end.

The concrete for the slabs and the top-floor columns was specified to have a crushing strength of 2500 lb. per square inch and that for the first-floor columns 3750 lb. per square inch at 28 days. The floors were designed for an imposed load of 80 lb. per square foot.

To allow sufficient room for the entrance of large vehicles on the ground floor, columns 9B and 9C (*Fig.* 2) are carried at first-floor level by two plate girders on to a central column. The connection of the concrete column to the steel girders was made by welding the fifteen 1¼-in. square bars of the column to a 4-in. thick steel plate which was spot welded at its edges to the top flanges of the girders.

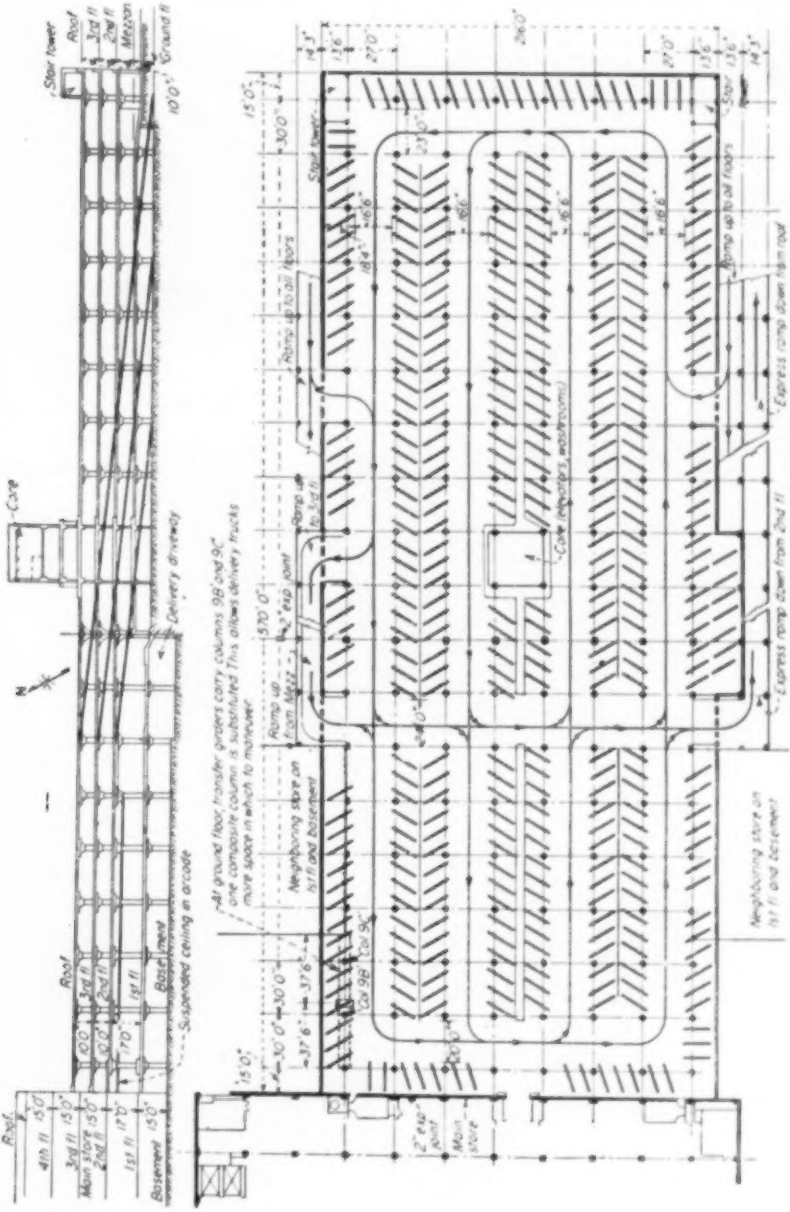


Fig. 2.—Garage in the U.S.A.: Second-floor Plan and Longitudinal Section (see page 336).

Revetments for Sea Defence.

NEW types of revetments that can be quickly built are shown in the illustrations. These are formed of interlocking precast concrete blocks laid without mortar and are therefore flexible when subjected to the action of waves or to settlement.

The block shown in *Fig.* 1 (known as the "Sealock") is square on plan, and the lower halves of two opposite sides have a horizontal projecting ledge about half the length and depth of the block. At each side of these projections are corner recesses. The blocks are laid in staggered rows, the projecting lugs fitting in the recesses of adjacent blocks. The blocks measure 1 ft. by 1 ft. by 4 in. with ½-in. projections and recesses. The joints are sealed with bitumen. The "Stormfender" block (*Fig.* 2) measures 1 ft. by 1 ft. by 6 in. and has ribs ½ in. deep.

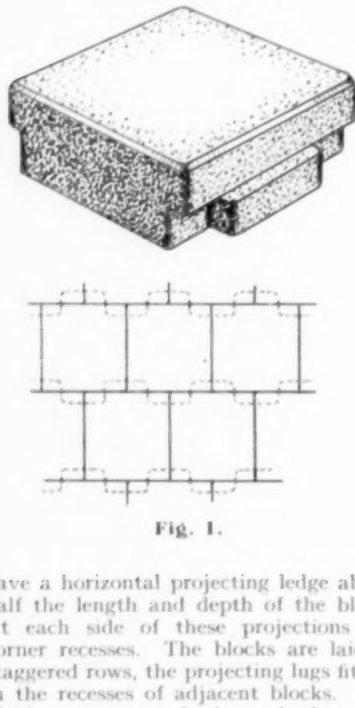


Fig. 1.

Both types of block are designed for use within frames with the object of localising damage if any of the blocks are torn away during storms. The framework is composed of solid type units (*Fig.* 2) four abreast on end sunk into the ground so that the lower halves provide anchorage. The blocks within the frames are interlocked to one another and also to the frames; the faces subjected to the action of the waves are smooth, whilst the under surfaces are keyed to the foundation. The toe of the revetment is partly sunk in the ground, and comprises three rows of interlocking blocks on end.

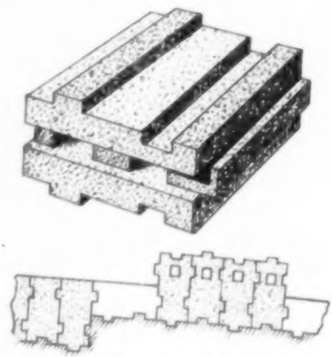


Fig. 2.

If it is desired to break the force of the waves some of the blocks may be laid to project above the general face of the revetment (*Fig.* 3). These blocks may also be used for stepped or vertical walls. Patents for the system have been applied for by Associated British Industries, of Liverpool.

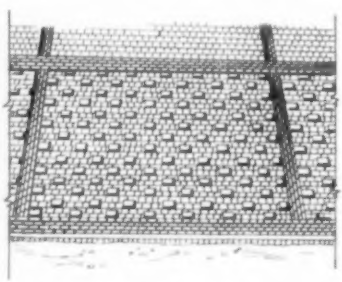


Fig. 3.

German Concrete Road-making Machines.

RECENT developments in the design of concrete road-making machines in Germany have been in the direction of high compacting efficiency, ease of adjustment over a wide range of widths and thicknesses, ability to negotiate curves, and convenience in transporting the plant. Present-day machines consolidate almost exclusively by surface vibration. They consist essentially of a levelling beam, a vibratory compactor, and a smoothing beam, and in one pass it is possible to achieve good consolidation of a slab up to 2 ft. thick cast in one course. The following descriptions and illustrations of some of these machines are taken from an article by J. Theiner in "Der Bauingenieur" for November 1954.

The machine made by the Allgemeine Baumaschinen-Gesellschaft mbH., of Hameln/Weser, is shown in *Fig.* 1. Spreading of the concrete slightly proud of the finished surface is effected by means of a roller after preliminary spreading and compaction by paddle-shaped blades. The compacting beam, which is about 20 in. wide and convex at the bottom, has from three to six out-of-balance weights spaced 3 ft. 8 in. apart; the number of weights depends on the effective width of the machine, and their frequency is variable between 50 and 70 cycles per second. The front edge of the beam is lifted by eccentrics at intervals of one or two seconds, depending on the rate of progress of the machine, while the rear edge is maintained at the desired level of the road surface. The beam also has a stepping movement, whereby pushing of the concrete is avoided and air is expelled. The finishing of the slab is achieved by two oscillating beams. The front beam has a frequency of 50 cycles per second and is driven by a 5-h.p. motor mounted upon the second smoothing beam. The width of the machine can be varied in increments of 10 in. between about 8 ft. and 25 ft. by changing the spreading roller, the compacting beam, the smoothing beam, and three rods. Vertical adjustment of the working elements of the machine to 14 in. below rail level makes it possible to consolidate the formation as well as the concrete. Differential couplings are fitted which enable the machine to negotiate curves. The machine can be transported by a lorry. A six-speed gear-box is provided. The machine can be driven by electric, diesel, or petrol motor. The same firm also produces a manually-controlled machine propelled by hand-wheels on each side (*Fig.* 2). It has no smoothing beam, but only a levelling beam and a vibrating beam which does not have an up-and-down motion as in the larger machine. The working width of this machine can be varied between 5 ft. and 16 ft. 6 in. The vibrating beam is provided with from one to four out-of-balance weights driven by a 6-h.p. electric, petrol, or diesel motor.

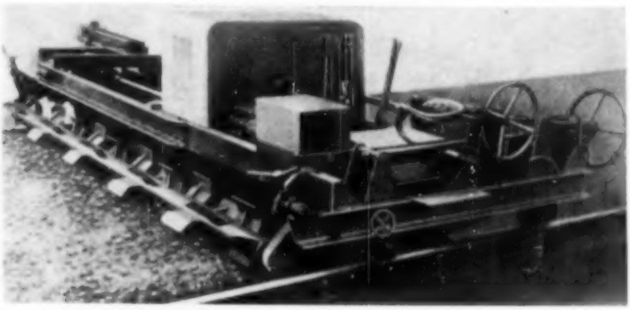


Fig. 1.

The Bavarian firm of Sonthofen makes a vibratory machine incorporating either

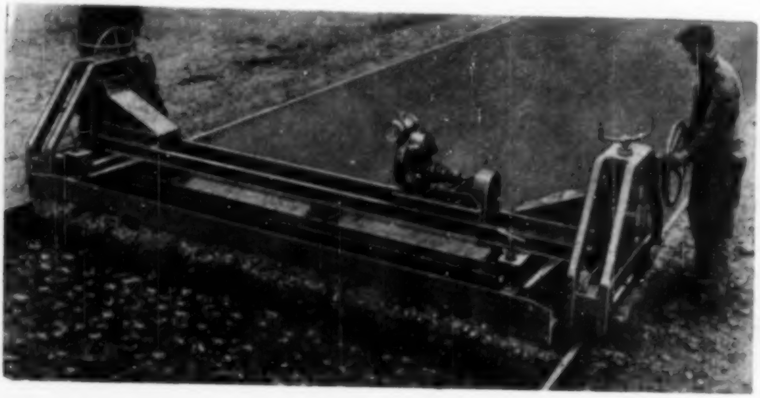


Fig. 2.

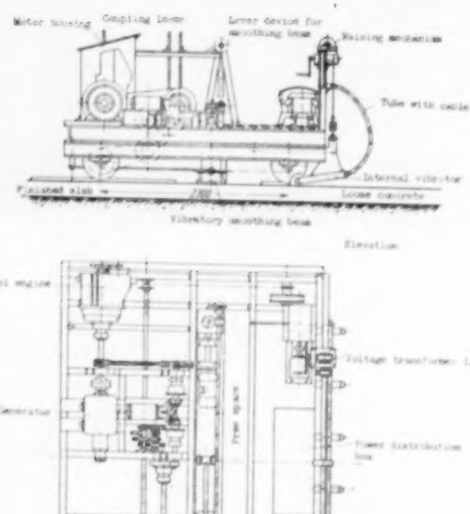

Motor housing
Coupling lever
Lever device for
smoothing beam
Raising mechanism
Tube with cable
Internal vibrator
Finished slab
Loose concrete
Vibratory smoothing beam
Elevation
Diesel engine
Generator
Free space
Voltage transformer II
Power distribution
box
Voltage transformer I

Fig. 3.

surface or immersion vibrators (*Fig.* 3). The vibratory beam is used for consolidating thin slabs, and immersion vibrators spaced about 2 ft. apart for the thicker slabs. The vibrating beam comprises separate parts each of which is separately actuated. This is claimed to produce more uniform compaction over the entire working width. There is no levelling beam, the vibrating beam being followed by a vibratory smoothing beam for finishing the surface. The working speed is up to 3 ft. per minute, and the machine is supplied in widths of 5 ft. 6 in. to 26 ft. 6 in.

Dingler-Werke KG, of Zweibrucken, make a machine for compacting the sub-grade and concrete slabs up to 6 in. thick. The working width is adjustable from 10 ft. to 25 ft. and has levelling, ramming, and vibrating beams. The maximum vertical adjustment is about 12½ in. The levelling beam has a transverse motion of 2 in. and a frequency of 140 oscillations per minute. The ramming beam has a frequency of 160 strokes per minute with an amplitude of 2 in. to 2¾ in., and is followed by a vibrating beam with a frequency of 3250 vibrations per minute. The machine travels at 6 ft. per minute.

The same firm supplies the larger machine shown in *Fig.* 4. The working width is from 10 ft. to 25 ft., and the machine is suitable for the compaction of one-course and two-course slabs 2 ft. thick. The beams are vertically adjustable up to 14 in. The levelling beam operates at a frequency of 115 oscillations per minute with an amplitude of 2 in. The ramming beam can be adjusted to varying angles in relation to the surface of the slab, and has adjustable out-of-balance weights operating at a frequency of 70 cycles per second. The smoothing beam, which follows the ramming beam, also has a transverse motion, a frequency of 115 oscillations per minute and an amplitude of 2½ in. The machine is fitted with gears for speeds of 3 ft. 6 in. and 23 ft. per minute. A manually-controlled vibratory finisher is supplied for working widths of 5 ft. to 14 ft. 9 in. This machine has a levelling beam and a vibrating beam, the angle of which can be adjusted. A separate smoothing element can be fitted if desired.

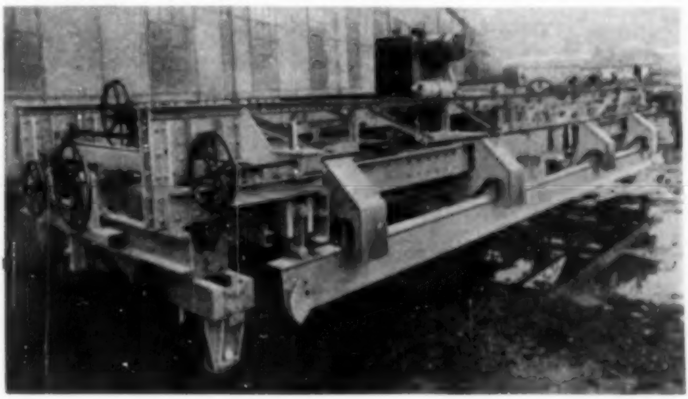


Fig. 4.

The machine (*Fig.* 5) made by Otto Kaiser, St Ingbert and Oberlahnstein, has an oscillating levelling beam as well as two compacting beams, one of which is a ramming and the other a vibrating beam. The vibrating beam serves as a smoothing element, and, like the spreading beam, has a transverse movement of 2 in. to 3 in. and a frequency of 39 cycles per minute. Vibration is produced by four out-of-balance weights whose frequency can be varied between 37 and 75 cycles per second. The ramming beam, which weighs 6 cwt., works at 160 cycles per minute with an amplitude of 3½ in. The machine is adjustable for working widths between 8 ft. and 12 ft. 4 in.

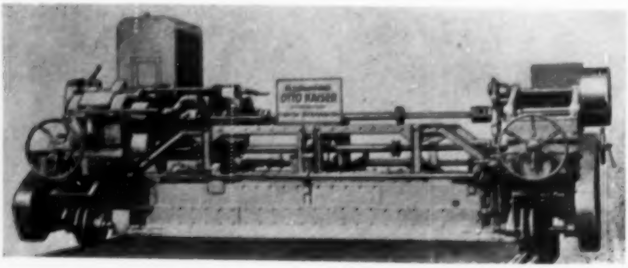


Fig. 5.

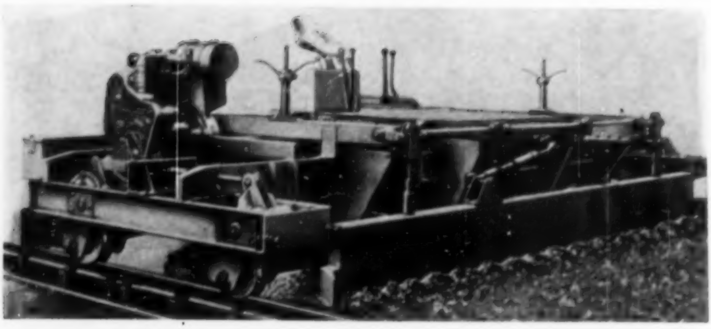


Fig. 6.

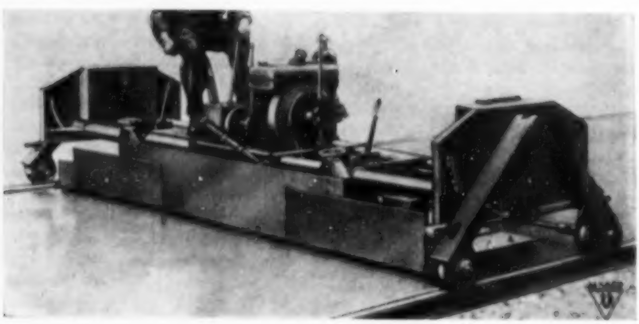


Fig. 7.

The two compacting elements can be separately lowered a distance of 1 ft. The working speeds are 2 ft. and 4 ft. 6 in. per minute.

The "Betonstrasse" machine made by Joseph Vögele AG, of Mannheim, consists of a levelling compactor, a vibrating beam, and a smoothing element, and can be used for working widths from 10 ft. to 25 ft. The levelling beam has an oscillatory motion with a frequency of 50 cycles per minute and an amplitude of 3 in. The angle of the beam is adjustable, so that the concrete placed in front of it is levelled and partially compacted. The actual compaction is done by the vibrating beam which follows it. This vibrating beam is operated by a system comprising two masses (the Schieferstein system) which vibrate with a phase difference of 180 deg. and thus balance each other, whereby the transmission of vibrations to the machine and to the rails is avoided. The smoothing element is of similar construction to the levelling beam, and has a transverse motion of 70 cycles per minute and an amplitude of 3 in. The working speed is 4 ft. 6 in. per minute. Curves can be negotiated by the provision of a differential gearing. The machine can be adjusted 10¾ in. vertically.

The "Hydraulik" machine (*Fig.* 6) has hydraulic control gear that is operated from the driver's platform and enables the levelling, compacting, and smoothing beams to be raised or lowered through 1 ft. 8 in. The amplitude is 1 in., so that one-course slabs up to 2 ft. thick can be compacted in one pass. The working speed can be varied from 14 in. to 4 ft. 8 in. per minute. The working width can be varied between 10 ft. and 25 ft.

The same firm's "Junior" machine (*Fig.* 7) is constructed for working widths of 5 ft. to 12 ft. 3 in. The chassis is of tubular construction and is adjustable to any desired working width. The vertical adjustment is 18 in. The total weight of the machine, with a working width of 12 ft. 3 in., is 1·6 tons. The levelling beam, the angle of which is capable of adjustment, has an amplitude of 3 in. and a frequency of 70 cycles per minute and it also serves as a smoothing unit. The vibrating beam works at 3000 to 4500 vibrations per minute, and has an amplitude of 1 in., and it is claimed that a slab 16 in. thick, of dry consistency, can be compacted.

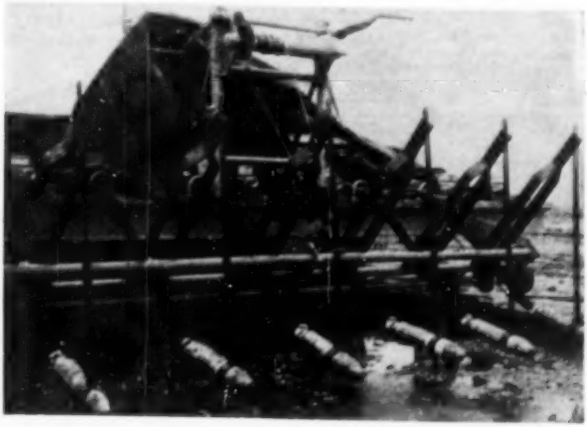


Fig. 8.

Wacker KG, of Munich, use immersion vibrators operating at 150 cycles per second to compact thick concrete slabs. For a working width of 12 ft. six of these vibrators (*Fig.* 8) are mounted on the back of a vehicle, and can be raised and lowered. For working widths up to 25 ft. a similar arrangement, but movable in the transverse direction, can be employed. An advantage claimed for this type of machine is that the vibrators can be quickly removed from and replaced on their mountings, and are thus readily available for use in other concrete work.

Expansion Joints.

The fifth edition of Dr. Kleinlogel's well-known book* deals with expansion joints in buildings, foundations, roofs, walls, slabs, hydraulic structures, pressure pipes, bridges, roads, etc. It is an exhaustive study of the problems of expansion joints in concrete structures, and the great number of examples given are a valuable source of reference. Five of the types of joint which may not be well known in this country are taken from this book and illustrated in the following.

Fig. 1 is an expansion joint in a beam in which sheet zinc is bent to the shape of the joint. A V-shaped fold at the top allows longitudinal movement of the beam, and the metal surfaces in contact reduce friction. On the underside of the beam the zinc is lapped to make the joint weatherproof.

Fig. 2 is an expansion joint in a roof slab. A metal strip (1) is shaped as shown and placed in kerbs formed at the edges of the joint. The joint is sealed with asphalt and allows longitudinal movement of the slab.

Fig. 3 is an expansion joint for a reinforced concrete pipeline carrying water under pressure. There is an external reinforced concrete ring (1), and two layers of bituminous felt (2) between the pipe and the ring. Waterproofing is provided by a copper strip which is bent to allow for expansion and bolted to adjoining pipes. The ends of the pipes

* "Bewegungsfugen im Beton-und Stahlbetonbau." By A. Kleinlogel. (Berlin: Wilhelm Ernst & Sohn. 1954. 270 pages. 560 drawings and photographs. Price 24 D.M.)

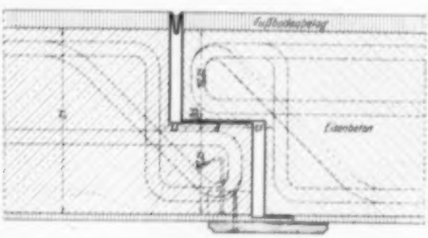


Fig. 1.

Fig. 2.

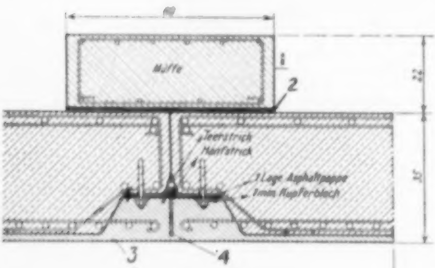


Fig. 3.

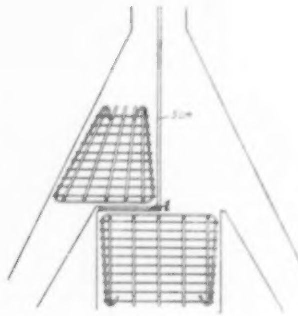


Fig. 4.

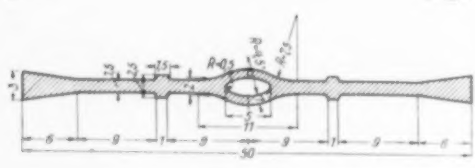


Fig. 5.

are covered with bituminous felt; bituminous rope is wedged into the V-shaped groove formed by the ends of the pipes, and hemp rope is placed in the bend in the copper strip. The waterproof lining on the inside of the pipe (3) is slotted at the joint (4) to predetermine the position of cracks. A typical arrangement of the reinforcement is also shown.

Fig. 4 is an expansion joint in a silo. A sliding joint is formed in the lower part of the walls at the junction with the hopper-bottom. Two steel-plates (1) are used to reduce friction. A typical arrangement of the reinforcement is shown.

Fig. 5 shows the cross section of a rubber strip used in Germany for weather-proofing expansion joints in reinforced concrete; it is similar in shape to some also made in this country.

Collapse of a Grain Elevator.

A LARGE reinforced concrete grain elevator built less than a year ago collapsed (*Fig.* 1) at Fargo, in the U.S.A., in June last. There were no witnesses. The Dean of the School of Engineering, North Dakota State College, is reported in "Engineering News-Record" as stating that an inspection of the site indicated evidence of failure due to shearing of the underlying soil. Movement of the soil to the south apparently permitted the north side of the foundation to settle, tilting the structure to the north and causing excessive longitudinal tensile stresses in the walls. The longitudinal axis of the structure extends east and west. The lower part of the silos broke into sections about 15 ft. long. The upper part was completely shattered by impact with the ground. To the south of the structure along its entire length and for a distance outward of about 60 ft. the ground was forced upward as much as 15 ft. by the shifting of underlying soil. The owner expressed the belief that the collapse was caused by an explosion.

The elevator was completed in August 1954 and consisted of twenty circular silos 19 ft. diameter and 120 ft. high. A head-house extended to a height of 198 ft. above ground. The foundation consisted of interlocking sheet piles around the perimeter driven to a depth of 18 ft. and topped with a concrete slab 2 ft. 6 in. thick. Some settlement of the elevator occurred prior to the collapse, but apparently it had not appeared excessive to the owner who moved the grain to correct the listing.

Fig. 1.

A Building to Resist Earthquakes.

A REINFORCED concrete framed building has recently been constructed in Tokyo to provide offices in Japan for the U.S.A. magazine "Reader's Digest". The building, which is fully described in a recent number of "Engineering News-Record", is a two-story structure, 25 ft. high, 54 ft. wide and 200 ft. long, founded on piles. Almost the whole of the exterior of the building is glazed, only the ends having solid walls. All the partitions are movable and the frame has to resist all lateral forces without any assistance from cross walls. A cross section through the building is shown in *Fig.* 1.

The ground floor is a 6-in. solid slab supported by longitudinal external edge beams, the concrete walls of the basement, a central beam spanning between the main columns and by transverse beams at 18 ft. intervals. The first floor and roof are of in situ trough construction, the ribs being 10 in. deep by 6 in. wide and the topping 3 in. thick. On the first floor the ribs are at 2 ft. 2 in. centres and on the roof 3 ft. centres. In both cases the ribs span on to beams at 18 ft. intervals. The cross beams are continuous over two spans of about 27 ft. and are supported at their outer ends by raking columns with pinned joints and by a central column with which they are monolithic.

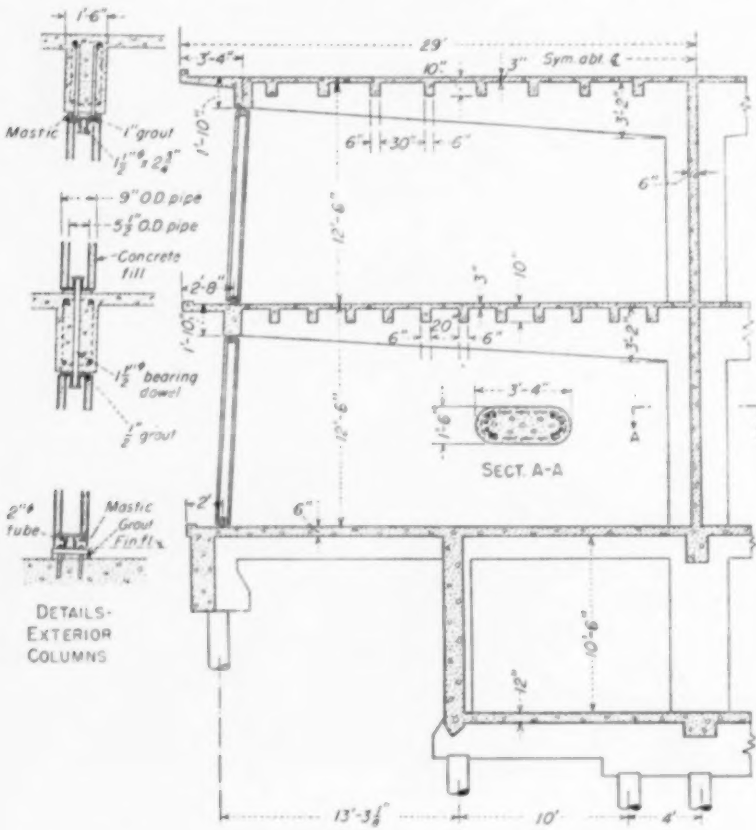


Fig. 1.—Cross Section.

The depth of these beams increases from 1 ft. 10 in. at their outer ends to 3 ft. 2 in. at the junction with the central column. At the outer ends of the beams there is a longitudinal beam 1 ft. 10 in. deep by 1 ft. 6 in. wide, and between the central columns there is a 6-in. thick reinforced concrete wall extending in height from the ground floor to the roof.

Hinged Columns.

The outer columns are placed about 2 ft. outside the line of windows and each column comprises a 5½ in. diameter steel pipe, which carries the loads from the beams, inside a 9 in. diameter steel pipe, the space between the two pipes being filled with lightweight concrete for fire-protection. To provide better resistance to transverse forces these columns are inclined towards the interior of the building at a slope of about ⅜ in. per foot. The connections to the beams at the top and bottom of each column permit a small amount of rotation. At the first floor a dowel passing through the spandrel beam, but not bonded to the concrete, transmits the axial load from the upper to the lower column. The central column is of reinforced concrete, 3 ft. 4 in. deep by 1 ft. 6 in. wide, and is designed to resist the axial loads and bending moments due to the weight of the structure, imposed loads and seismic forces.

Resistance to Earthquakes.

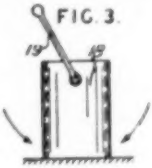
Tests have been carried out to determine the natural period of vibration of the building in the transverse and longitudinal directions. The tests were made with a centrifugal force agitator, the vibrations being recorded by a seismograph. The measured periods were 0·18 seconds and 0·12 seconds in the transverse and longitudinal directions respectively, and the damping ratios 1·70 to 1 in the transverse direction and 2·11 to 1 in the longitudinal direction. These values are stated to be more favourable than those generally found in comparable buildings and suggest that the building may be safe in severe earthquakes as the response to seismic motion would be comparatively slight and the vibrations would be quickly damped.

The building was designed by Mr. Antonin Raymond and Mr. L. L. Rado, architects and engineers, and Mr. Paul Weidlinger, structural engineer, of General Engineering Associates.

Patents Relating to Concrete.

A Test for Consistency.

FIG. 3.



A CYLINDRICAL mould (18) for producing specimens, for example of concrete, has a pivoted handle (19) which is dropped alternately against opposite sides of the mould to impart shocks thereto and cause the mass therein to subside. The number of shocks required may be previously determined by a test for consistency—No. 691,218. S. Thoulow. December 29, 1950.

Prestressed Concrete.

IN the manufacture of prestressed concrete products which contain post-tensioned wire, the wires are arranged in position in the moulds and the concrete is placed. Whilst setting occurs, the wires are vibrated or drawn to and fro and an electric current is passed through them so as to raise the temperature of the concrete immediately surrounding the wires to over 100 deg. C., thus destroying any bond which may have occurred, preventing the formation of bond, and allowing the wires to be tensioned, which may be done whilst they are hot, and anchored after the concrete has hardened.—No. 674,232. Dowsett Engineering Construction, Ltd., and R. S. V. Barber. March 6, 1950.

Professional Announcement.

Mr. A. J. Harris, B.Sc. (Eng.), A.M.I.C.E., has relinquished his appointment as a director of the Pre-Stressed Concrete Co., Ltd., and has started in private practice at 128 Ashley Gardens, London, S.W.1. Telephone, Victoria 6924.

Pulverised-Fuel Ash as an Aggregate.

The Cementation Co. Ltd. has agreed to take the whole output of pulverised-fuel ash—some 65,000 tons a year—produced at the Battersea power station of the Central Electricity Authority. The ash will be converted into a lightweight aggregate by the "Sinterlite" process developed by Mr. F. P. Somogyi.

Crushing Machines.

British Standard No. 2595 : 1955, entitled "Descriptions and Methods of Measuring Sizes and Outputs of Crushing Machinery" (issued by the British Standards Institution at a price of 2s. 6*d*.) contains five pages of notes and one sketch in giving recommended methods of describing the sizes of the machines and methods of measuring their "outputs".

Trade Notice.

The United Strip and Bar Mills, whose manufacturing and trading activities have been amalgamated with those of Messrs. Steel, Peech & Tozer for many years, has ceased to trade under a separate title. Their activities and trading are now carried out in the name of Steel, Peech & Tozer, a branch of the United Steel Companies, Ltd.

DATA FOR PRICING REINFORCED CONCRETE.

Materials.

(Delivered in London area.)

Aggregates (per cu. yd.).—Washed sand, 25s. 1*d*. Clean shingle: ¾ in., 21s. 5*d*.; ⅜ in., 24s. Pit ballast, 24s. 6*d*.

Cement (per ton, delivered at Charing Cross).—
Portland cement, 6 tons and upwards, 101s. 6*d*. 1 ton to 6 tons, 113s. 6*d*. Paper bags and non-returnable jute sacks included.
Rapid-hardening Portland, 10s. 0*d*. above ordinary Portland.
Aquacrete and 417, 32s. 6*d*. above ordinary Portland; paper bags included.
Colorcrete (buff, red, and khaki), in 6-ton loads, 143s.; paper bags included.
Snowcrete, 262s., inc. paper bags.
"Super-Cement," 32s. 6*d*. per ton above ordinary Portland cement; paper bags included.
High-alumina cement: per ton, 307s.; 2 tons, at 296s. 9*d*.; 4 tons, at 291s. 9*d*.; 6 tons, at 288s. 3*d*.
Snowcem paint, 71s. per cwt. including containers.

Shuttering.—1" and 1½" deal sawn shuttering boards, £95–£100 per standard.

Reinforcement.—Mild steel bars, B.S. 785 (per cwt.); ⅝ in. to 2½ in., 45s. 9*d*.; 5/16 in. to ½ in., 47s. 6*d*.; ¼ in., 48s. 3*d*.; 3/16 in., 49s. 9*d*.

Materials and Labour.

(Contracts up to £5000. Including 10 per cent. profit.)

Portland Cement Concrete, 1 : 2 : 4.—
Foundations, 2s. 7½*d*. per cu. ft. Columns, 3s. 6½*d*. per cu. ft. Beams, 3s. 3½*d*. per cu. ft. Floor slabs, 4 in. thick, 9s. 4½*d*. per sq. yd.; Do., 5 in., 11s. 10*d*.; Do., 6 in., 13s. 6*d*.; Do., 7 in., 15s. 10½*d*. Walls 6 in. thick, 15s. per sq. yd. Add for hoisting above ground level, 3s. 9½*d*. per cu. yd. Add for rapid-hardening Portland cement, 3s. per cu. yd.

Reinforcement.—Mild steel bars (B.S. 785), including cutting, bending, fixing, and wire (per cwt.)—¼ in. to ⅜ in., 79s. 3*d*. 7/16 in. to ⅝ in., 72s. 10*d*. 11/16 in. to 2½ in., 66s. 10*d*.

Shuttering and Supports.—
Walls, 214s. 2*d*. per square.
Floors (average 10 ft. high), 198s. 6*d*. per square. In small quantities, 2s. 7½*d*. per sq. ft.
Columns, average 18 in. by 18 in. (per sq. ft.), 3s.; in narrow widths, 3s. 10*d*.
Beam sides and soffits, average 9 in. by 12 in. (per sq. ft.), 2s. 11½*d*.; in narrow widths, 3s. 5½*d*.
Raking, cutting, and waste, 6½*d*. per lin. ft.
Labour on splays, 3½*d*. per lin. ft.
Small fillets to form chamfers, 6½*d*. per lin. ft.

Wages.

The rate of wages on which the above prices are based are: Carpenters and joiners, 4s. 1½*d*. per hour (carpenters 2*d*. a day tool money); Labourers, 3s. 7*d*.; Men on mixers and hoists, 3s. 10*d*.; Bar-benders, 3s. 10½*d*.

MISCELLANEOUS ADVERTISEMENTS.

Situations Wanted, 3d. a word : minimum, 7s. 6d. Situations Vacant, 4d. a word : minimum, 10s. Other miscellaneous advertisements, 4d. a word : 10s. minimum. Displayed advertisements, 30s. per column inch. Box number 1s. extra. The engagement of persons answering these advertisements is subject to the Notification of Vacancies Order, 1952.

Advertisements must reach this office by the 23rd of the month preceding publication.

SITUATIONS VACANT.

SITUATIONS VACANT. THE TRUSSED CONCRETE STEEL CO., LTD., have vacancies in their London, Birmingham, Glasgow, and Manchester offices for reinforced concrete designers and detailers. Five-days' week. Pension scheme. Apply, giving full particulars of age, education, and previous experience, to the SECRETARY, Truscon House, 35–41 Lower Marsh, London, S.E.1.

SITUATIONS VACANT. Reinforced concrete designer-detailers wanted by British Co. in Mombasa (Kenya), Kampala (Uganda), and Dar-es-Salaam (Tanganyika). Candidates should have had at least five years' experience. Salary according to ability and experience. Free air passages, two months' paid home leave by air each 2½ years, bonus and pension schemes. Applications will be treated in strict confidence. Write Box R13/4/55, 95 Bishopsgate, London, E.C.2.

SITUATIONS VACANT. Reinforced concrete designers and detailers required. Permanent position with good prospects. Pension scheme, five-days' week, and luncheon vouchers. Write or telephone for interview. E. J. COOK & CO. (ENGINEERS), LTD., 54 South Side Clapham Common, London, S.W.4. MACaulay 5522.

SITUATIONS VACANT. Consulting structural engineers, Westminster, require first-class designer-draughtsman and a detailer experienced in reinforced concrete and/or steel framed buildings and foundations. High salaries and good prospects for suitable applicants. Write in confidence stating age, qualifications, and details of experience. Box 4167, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Designer-draughtsmen required for London head office of old-established reinforced concrete engineers. Applicants must be familiar with design of reinforced concrete frames and all forms of reinforced concrete floor construction. The post is permanent, progressive, and pensionable. Existing holiday arrangements would be respected. Substantial salary for experienced men. Write Box 4170, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Senior reinforced concrete designers wanted by leading reinforced concrete engineers and contractors. Must be fully conversant with Code of Practice, L.C.C. Bye-Laws, and able to design light-framed structures from estimating stage to final details. Five-days' week. Pension scheme. Progressive position. Starting salary from £900 upwards according to ability. This year's holiday arrangements honoured. Juniors also required, similar conditions. Write Box 4172, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Detailer-draughtsman required for varied reinforced concrete work. Permanent, progressive, and superannuated post. 36½ hours' week. Alternate Saturdays. Telephone for appointment (Mr. Disney) ROM RIVER CO., LTD., Euston 7814.

SITUATIONS VACANT. Consulting engineers require civil engineering, structural, and architectural designer-draughtsmen for their Manchester office for work of varied character on major industrial development schemes. A non-contributive pension scheme is in operation and generous salaries will be offered to suitable applicants. Reply in first instance, giving age, experience, and when available, to C. S. ALLOTT & SON, North Parade, St. Mary's Parsonage, Manchester, 3.

DESIGNERS
DETAILERS

A rapidly-expanding company of reinforced concrete engineers requires designers and detailers, in Manchester and Nottingham, for a wide variety of reinforced and prestressed concrete work. Excellent opportunities and experience for competent men. Good working conditions. Salaries dependent upon experience.

Matthews & Mumby Limited,
129 Stockport Road,
Manchester, 12.

SITUATIONS VACANT. Consulting engineers require civil engineering, structural, and architectural designer-draughtsmen for a major industrial development scheme in the North-East. It is proposed to provide accommodation at an hotel situated on sea front within 7 miles of site. Alternatively, generous subsistence allowance would be allowed. Transport to and from site will be provided. Interviews will be arranged, and generous salaries offered to suitable applicants. Non-contributive pension scheme in operation. Reply in first instance, giving age, experience, and when available, to C. S. ALLOTT & SON, North Parade, St. Mary's Parsonage, Manchester, 3.

SITUATIONS VACANT. Reinforced concrete designers (senior and junior) required by consulting engineers for varied and interesting building frames and industrial structures. Good prospects. Five-days' week. Lunch vouchers. Apply with details of experience, etc., to JOHN F. FARQUHARSON & PARTNERS, Chartered Structural Engineers, 34 Queen Anne Street, London, W.1. LANgham 6081.

SITUATIONS VACANT. Reinforced concrete detailers required for London office. Previous experience in similar capacity necessary. Attractive conditions of employment. Apply in writing, giving brief particulars of education, experience, age, and quoting L.128, to BRAITHWAITE & CO. ENGINEERS, LTD., 14–16 Regent Street, London, S.W.1

SITUATIONS VACANT. Civil engineering designer-detailers are required for varied and interesting work in N.W. London. Permanent pensioned employment. Five-days' week. Staff canteen. Sports club facilities. Apply in writing, stating age, experience, and approximate salary expected, to Personnel Manager (D.1), JOHN LAING & SON, LTD., Building and Civil Engineering Contractors, London, N.W.7.

SITUATIONS VACANT. Air Ministry, Works Designs Branch, require in London structural engineering designer draughtsmen for reinforced concrete or structural steelwork with sound technical training, and several years' varied experience in design detailing of : (a) reinforced concrete construction for all types of buildings, or (b) steel-framed sheds, warehouses and similar buildings. Salaries up to £810 per annum, starting pay based on age, qualifications, and experience. Paid overtime. Posts non-pensionable with long-term possibilities. Natural born British subjects only. Write, stating age, qualifications, employment details, including type of work done, to any EMPLOYMENT EXCHANGE, quoting Order No. BOROUGH 2304.

SITUATION VACANT. Required by major oil company for employment in Venezuela, civil maintenance supervisor who would be required to assist in supervision of joinery, masonry, steelwork, construction/maintenance/repair of buildings, plants, jetties, ditches, erection of steel scaffolding, fire-bricking boilers and heat insulation, steam lines, stacks and ducts, etc. Must be capable of closely supervising and detailing foremen, chargehands, etc. Approximate age desirable 30/35 years, married or single. Suitable candidate preferably to have had some years' refinery experience, especially in fire-bricking and insulation work. Commencing salary in line with past experience. Family pension scheme. Post of career nature with three-years' tours. Local leave and leave in U.K. end of each tour. Write, giving full details, to Box ZU 761, DEACON'S ADVERTISING, 36 Leadenhall Street, London, E.C.3.

SITUATION VACANT. **Civil engineering assistant—dock** and harbour design experience—required by Westminster consultants. Salary £750 upwards adjusted according to experience and qualifications. Box 4182, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Reinforced concrete designer-detailer required by consultant in Westminster. Salary £700 to £800 according to experience. Details of qualifications and experience, please, to Box 4181, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Designers, detailers, and draughtsmen (all grades) required by engineers in London, W.1, area for structural reinforced concrete work. Salaries range up to £950 per annum. Write full details to Box 4179, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Civil engineering department of the COPPEE CO. (GREAT BRITAIN), LTD., 140 Piccadilly, London, W.1, requires following staff for interesting and varied colliery structures. Reinforced concrete and steelwork designers of ten years' experience, and reinforced concrete and steelwork detailers of three years' experience. Five-days' week. Pension scheme. Write, giving age, experience and salary required.

SITUATION VACANT. Wanted good architectural draughtsman for London office (public buildings). Box 4180, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete designer-draughtsmen required in London for varied and interesting work. Sound knowledge of design and practice and ability to produce quick and accurate work essential. First-class salaries and permanent positions for right men. For application form apply SIR BRUCE WHITE, WOLFE BARRY & PARTNERS, 1 Lygon Place, London, S.W.1. Telephone: Sloane 0431.

CITY OF LIVERPOOL.

CITY BUILDING SURVEYOR'S DEPARTMENT

Applications are invited for appointments.

ASSISTANT STRUCTURAL ENGINEERS

Salary £675 to £900 per annum (A.P.T. IV/V). The commencing salary will be determined, with a maximum of £795, according to qualifications and experience. Applicants should be Chartered Structural Engineers and have had a wide experience in the design of structures in steelwork and reinforced concrete and be capable of checking designs in accordance with the British Standard Codes of Practice.

Applications will also be considered from GRADUATE MEMBERS of the Institution of Structural Engineers. Salary £560 to £640 per annum (A.P.T. II), increasing to A.P.T. IV/V on election as Associate Members.

Application forms, obtainable from the City Building Surveyor, Municipal Buildings, Liverpool, 2, must be returned (accompanied by copies of not more than three recent testimonials), by Monday, 3 October, 1955.

The appointments are superannuable and subject to the Standing Orders of the City Council. Canvassing disqualifies.

THOMAS ALKER,

Town Clerk.

Municipal Buildings,
Liverpool, 2. (J4034.)

A well founded and progressive firm of **REINFORCED CONCRETE DESIGNERS AND CONTRACTORS** specialising in the construction of important buildings incorporating precast reinforced concrete structural and walling members, invite applications for the following appointments:

1. **WORKS MANAGER** for modern works now being considerably enlarged and re-tooled. Although preference will be given to applicants who have had previous experience in the production of heavy precast concrete units, this will not be regarded as so important as evidence that they possess the ability to organise and co-ordinate the production of several departments and preparedness to get to personal grips with technical problems. Applicants should preferably be qualified Civil or Mechanical Engineers and must have held positions of responsibility in Civil Engineering or Heavy Industry.
2. **PRODUCTION ENGINEER.** Applicants should be qualified Mechanical Engineers of proven practical ability. The work which offers considerable scope will be concerned, *inter alia*, with mould design, planning of factory plant and stackyard layout, retooling of reinforcement assembly shops, production planning, and the design of specialised jigs and site erection equipment.
3. **AREA AGENT** to take charge of site erection and ancillary civil engineering and building works on a group of contracts. Preference will be given to civil engineers with experience of general building work and of heavy foundations in made-up ground, in situ and precast concrete construction.

All the above appointments are permanent and will be pensionable, and offer excellent scope and prospects in a medium sized and rapidly expanding organisation. Good salaries will be paid commensurate with experience, and assistance may be given with accommodation after a suitable probationary period. Applicants should give full particulars in chronological order of their education, training, qualifications, positions held and salaries received. Box No. 4183, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete engineers require detailers and junior draughtsmen. Write, giving age, experience, and salary required to CONSIDERE CONSTRUCTIONS, LTD., 72 Victoria Street, London, S.W.1.

SITUATIONS VACANT. SIMON-CARVES, LTD., require two civil engineers age about 25. The work will include test-boring on sites and soil tests in the laboratory. Applicants should be graduates, or at least of H.N.C. level, and must have had good training in soil mechanics and site investigation. The posts are permanent and offer good scope. Working conditions are good and a pension scheme is in operation. Write, quoting reference BS. 56, to Staff and Training Division, SIMON-CARVES, LTD., Cheadle Heath, Stockport.

SITUATIONS VACANT. Draughtsmen—IMPERIAL SMELTING CORPORATION, LTD., Avonmouth, Bristol, requires experienced mechanical, electrical and structural/civil draughtsmen for design and detail work in connection with chemical and metallurgical plant and equipment. Salaries, working conditions and welfare facilities are good, and good prospects of promotion exist for young men holding or prepared to obtain H.N.C. or equivalent. Bus and train services to and from the works gates. Write to PERSONNEL MANAGER for application form, giving brief details of age, qualifications and experience, and quoting reference D/ECE.

(*Continued on page lxviii.*)

THE KLEINE CO. LTD.

Designers of, and contractors for, Reinforced Concrete Frame Buildings and Specialists in Fire-resisting Hollow-Brick Floors since 1905

HAVE VACANCIES FOR

SENIOR R.C. DESIGNERS

R.C. DESIGNER-ESTIMATORS

R.C. DESIGNER-DRAUGHTSMEN (All grades)

BONUS MEASURERS

& TAKERS-OFF

These are all PERMANENT POSITIONS offering TOP GRADE SALARIES and exceptional opportunities for advancement.

Working conditions, in spacious and well-lighted offices, are excellent, and there is a non-contributory SUPERANNUATION SCHEME in operation.

Applicants are invited to write, giving fullest possible information concerning experience and stating the salary they consider to be a measure of their ability, to:

The Managing Director,
The Kleine Co. Ltd.,
9/13 George Street, Manchester Square, London, W.1.

SITUATION VACANT. Design assistant (general construction) required by the East African Railways and Harbours Administration Civil Engineering Department for one tour of 36–48 months on contract terms. Consolidated salary of up to £1,700 a year. Gratuity at 10 per cent. of total salary drawn during contract. Free passages for officer and family. Liberal leave on full salary. Candidates must be equally experienced in steel and reinforced concrete structural design. Write to the CROWN AGENTS, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2B/40744/CAR.

SITUATIONS VACANT. Reinforced concrete designer-draughtsmen and detailers required by Ashmore, Benson, Pease & Co., Stockton-on-Tees. Must be fully experienced in either designing or detailing reinforced concrete structures, foundations and other civil work. Maximum assistance given in obtaining accommodation. One house and two flats already available. Pension scheme, technical library, and sports facilities available. Apply, stating age, experience, etc., quoting reference "D", to STAFF PERSONNEL OFFICER.

SITUATIONS VACANT. The following are required immediately for new offices near Oxford Circus, and for work in a rapidly-expanding organisation:

1. Civil engineering draughtsmen.
2. Reinforced concrete: Designers and detailers.
3. Structural steelwork: Designers and detailers.
4. Drainage engineers and draughtsmen.
5. Tracers with at least two years' drawing office experience. Salary: £400–£450 per annum.
6. Men with an excellent knowledge of building construction capable of taking off materials' lists for ordering purposes.

High salary and good working conditions are offered. Pension scheme in operation. Five-days' week. Holidays honoured this year. Apply in writing to THE CHIEF DESIGNER, BRIAN COLQUHOUN & PARTNERS, 18 Upper Grosvenor Street, London, W.1.

CITY OF CARDIFF

APPOINTMENT OF

STRUCTURAL ENGINEERING ASSISTANTS

Applications are invited for the following appointments in the City Surveyor's Department:

(a) Senior Assistant Structural and Mechanical Engineer. A.P.T. Grade 6 (£825–£1000 per annum).

(b) Structural Engineering Assistant. Special Grade. (£650–£775 per annum.)

Candidates should possess the minimum qualifications and experience prescribed by the National Joint Council for Local Authorities' Administrative, Professional, Technical and Clerical Services for posts in the above-mentioned Grades.

General Conditions of Appointment may be obtained from the undersigned.

The Council will assist in providing housing accommodation for the successful applicants for a period.

Applications, accompanied by the names and addresses of three referees and endorsed "Structural Engineering Assistant, A.P.T. Grade", as the case may be, must be delivered to me not later than 21 September, 1955.

S. TAPPER-JONES,
Town Clerk.

City Hall, Cardiff.
July, 1955.

(Continued on page lxx.)

MISCELLANEOUS ADVERTISEMENTS.

(Continued from page lxix.)

SITUATIONS VACANT. Senior reinforced concrete designers required by Newcastle-on-Tyne company. Five-days' week. Annual bonus. Non-contributory pension scheme. Salary according to qualifications. Apply Box 4189, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Consulting civil engineer in Manchester requires experienced reinforced concrete and/or structural steelwork designers. Five-days' week. Salary according to qualifications and experience. Applications, stating age, qualifications, and experience, to BERTRAM DONE, 55 Cross Street, Manchester 2.

SCOTTISH GAS BOARD—GLASGOW DIVISION
GLASGOW DISTRICT
CIVIL STRUCTURAL ENGINEERING ASSISTANT

A vacancy exists in the Engineers' Office of the Glasgow Division of the Scottish Gas Board for a Civil/Structural Engineering Assistant, in Grade A.P.T. 6/8 (the maximum of which is £740 per annum), with placing according to qualifications and experience. Excellent promotional opportunities for the right person.

Applicants should be experienced in reinforced concrete design and detailing, have a knowledge of structural steelwork and building construction.

The post will be superannuable, and the successful candidate may be required to undergo medical examination.

Applications endorsed "CS/EO", stating particulars of experience, etc., should reach the undersigned not later than 14 days after publication of this notice.

D. F. YOUNG,
Divisional Controller.

6 George Square, Glasgow, C.2.

MANCHESTER
COLLEGE OF TECHNOLOGY

(Faculty of Technology in the University of Manchester)

Appointment of

LECTURER IN STRUCTURAL ENGINEERING

The Governing Body invites applications for a Lectureship in Structural Engineering in the College with the title and status of Lecturer in the University of Manchester.

Candidates should be graduates in Science or Technology and should possess a good knowledge of Theory of Structures. The person appointed will be required to undertake research work on Structures and to assist in lecturing and laboratory work in Structural Engineering.

Salary: £650 per annum, rising by annual increments of £50 to £1,350 per annum. Commencing salary according to qualifications. Superannuation under F.S.S.U., and family allowances.

Conditions of appointment and form of application may be obtained from The Registrar, College of Technology, Manchester, 1. The last day for the receipt of applications is Monday, 19 September, 1955.

B. V. BOWDEN,
Principal of the College.

HOLST & CO. LTD. have vacancies in their new Watford Office for Assistant Engineers, Designers and Draughtsmen, with experience in Reinforced Concrete Design, and also for University Graduates for training under Indenture.

Apply with full particulars to HOLST & CO. LTD., 46 Clarendon Road, Watford.

THE UNIVERSITY OF LEEDS

DEPARTMENT OF CIVIL ENGINEERING

Applications are invited for appointment as Lecturer in Civil Engineering at a salary on the scale £650 — £50 — £1,350 a year, according to qualifications and experience. Candidates should have an Honours Degree and practical experience in Public Works Engineering. Some experience in Public Health and/or Traffic Engineering will be an advantage. Applications (three copies) stating date of birth, qualifications, and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than 26 September, 1955.

SENIOR REINFORCED
CONCRETE DESIGNER

required by an Anglo-American Company who are leading Design and Construction Engineers to the Oil and Chemical industries.

This is a good opportunity for an experienced man over the age of 40 who desires more scope for his abilities, and who wishes to specialise in an industry with prospects.

The work will entail leading a small but efficient group of designers engaged in the design of foundations and reinforced concrete structures of oil refinery and chemical plants.

If necessary a period of special training will be given where the successful candidate is not experienced in this particular work. Preferably applicants should have had good general reinforced concrete experience, and should hold one or more of the following qualifications: B.Sc., A.M.I.C.E. or A.M.I.Struc.E.

The appointment will be permanent. Pension and life assurance and other benefits. Modern offices.

Apply in writing to:
Box 38/CSE,
DOWNSTONE LIMITED,
Temple Bar House,
Fleet Street,
London, E.C.4.

(Continued on page lxxii.

MISCELLANEOUS ADVERTISEMENTS.

(*Continued from page lxxi.*)

SITUATIONS VACANT. Structural draughtsmen with at least two years' experience in reinforced concrete or structural steel required for London professional office. Vacancies suitable for men requiring all-round experience and interested in taking up design, a knowledge of which will be an advantage. Five-days' week. Non-contributory pension scheme. Apply, stating full details of experience and salary required, to FARMER AND DARK, Romsey House, Tufton Street, London, S.W.1.

SITUATIONS VACANT. Designer-draughtsmen and juniors required for both normal and prestressed concrete work by concrete specialists. Salary range £600 to £800. Pension scheme and sports club facilities. Apply, giving fullest particulars, to CHIEF ENGINEER, PIERHEAD, LTD., Faggs Lane, Feltham, Middlesex.

DESIGN ASSISTANT WANTED

Design assistant required for Company manufacturing prestressed concrete. Variety of design in prestressed and reinforced concrete. Applicant should be familiar with the normal methods of structural analysis. Apply, giving full details and salary required, to Box 4190, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

JOHN LAING & SON LIMITED

Invite applications for the following technical staff vacancies in their Research and Development Department, Boreham Wood, Herts:

SENIOR CHEMIST.
Honours Graduate or A.R.I.C. with research experience and an interest in physical and inorganic chemistry with an engineering basis.

ASSISTANT CHEMIST.
As above, but intermediate qualification will be accepted.

SENIOR CONCRETE ENGINEER.
Graduate or A.M.I.C.E. with an interest and ample practical experience in concrete technology. Post-graduate studies in this subject are desirable but not essential.

ASSISTANT CONCRETE ENGINEERS.
As above but qualifications are not essential.

SOILS ENGINEER A.M.I.C.E.
With a good theoretical and practical background in soil mechanics. Post-graduate studies in this subject are desirable but not essential.

EXPERIMENTAL ASSISTANTS.
Engineering degrees and qualifications are not essential, but applicants must be adaptable and ready to tackle a wide variety of experimental and research work.

ASSISTANT PLANT DEVELOPMENT ENGINEER.
Graduate in Civil Engineering, but with a mechanical bent, or vice versa.

MECHANICAL DRAUGHTSMEN.
For work on plant development.

The above posts are progressive and pensionable. The work is varied and interesting, and holds attractive prospects in an expanding field. 5-days' week. Canteen and Sports Club facilities.

Apply in writing, stating age, qualifications and salary expected, to:

Personnel Manager (L.G.2),
John Laing and Son Limited,
Building and Civil Engineering Contractors,
London N.W.7.

SITUATION VACANT. Senior assistant required in the drawing office by civil engineering contractors specialising in foundations. Excellent prospects, salary, bonus, and pension scheme. Applications in writing stating age, experience, and salary required, to WEST'S PILING & CONSTRUCTION CO., LTD., Bath Road, Harmondsworth, West Drayton, Middlesex.

SITUATION WANTED.

SITUATION WANTED. Designer/draughtsman, nine years' experience in consulting engineer's office, requires position with consulting engineer or contractor. Salary £1000 per annum. Box 4186, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street London, S.W.1.

GRACE PERSPECTIVE COMPANY

Structural and Civil Engineering Technical Illustrations, Details, Tracings, etc.

Competitive quality. Estimates free.

Write or 'phone—47, Onslow Road, Richmond, Surrey (RIChmond 6506).

FOR SALE.

FOR SALE. Steel fencing stakes, chain link, etc. E. STEPHENS & SON, LTD., Bath Street, London, E.C.1. Clerkenwell 1731.

FOR SALE. Steel tubes and fittings ⅛in. to 8in. nominal bore. Prices on application. STEPHENS & SON LTD., Bath Street, London, E.C.1

FOR HIRE.

FOR HIRE. Lattice steel erection masts (light and heavy), 30 ft. to 150 ft. high, for immediate hire. BELLMAN'S, 21 Hobart House, Grosvenor Place, London, S.W.1.

STONE COURT AGGREGATES ★

General View of Plant at Rickmansworth.

ONE OF OUR MODERN CONCRETE AGGREGATES PLANTS

First-Class Washed graded concrete aggregates, and shingles for road dressing, coupled with efficient delivery, are at the service of contractors and Municipal Authorities in London, Berks, Bucks, Herts, and Middlesex Areas.

Our products include Washed Sharp Sand, all sizes of shingles, from 3/16" up to 2", either crushed or natural.

Special Specifications made to order.

STONE COURT BALLAST CO. LTD.

PORTLAND HOUSE, TOTHILL ST., WESTMINSTER, S.W.1

Telephone: Abbey 3456.

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